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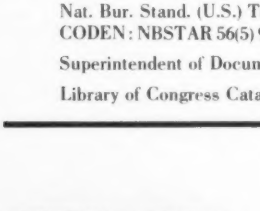

Cover: This shattered residence shows the destructive force of the February 1971 San Fernando, Calif., earthquake. See page 99.

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NATIONAL BUREAU OF STANDARDS
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The National Bureau of Standards serves as a focal point in the Federal Government for assuring maximum application of the physical and engineering sciences to the advancement of technology in industry and commerce. For this purpose, the Bureau is organized as follows:

The Institute for Basic Standards

The Institute for Materials Research

The Institute for Applied Technology

Center for Radiation Research

Center for Computer Sciences and Technology

The TECHNICAL NEWS BULLETIN is published to keep science and industry informed regarding the technical programs, accomplishments, and activities of NBS.

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One of the many examples of highway overpass collapses.

REPORT ON THE SAN FERNANDO EARTHQUAKE

A destructive earthquake struck the San Fernando, Calif., area on February 9, 1971, causing 64 deaths and one-half billion dollars damage. This Richter magnitude 6.6 shock was not a great earthquake, but it occurred in an area with a concentration of large and costly public facilities which sustained severe damage. Within 24 hours a team of NBS specialists was on the scene to record and report on structural damages. Dispatched at the request of the White House Office of Emergency Preparedness, four members of the NBS Building Research Division examined and photographed homes, schools, hospitals, roads, bridges, public services, and flood-control facilities. A major report summarizing their findings, and including some recommendations to minimize future earthquake damage, is now available.[1]

After careful study of the San Fernando area, the engineers agreed that present procedures used to update design regulations should be evaluated to find more expeditious ways to incorporate new knowledge into design. At the Olive View Medical Center, for example, the Psychiatric Unit collapsed, they believe, because of insufficient first-story column shear strength. The stresses used in the design were based on an older building code. Had those incorporated in a 1966 code been applied, which require the use of additional lateral reinforcement in the columns, the collapse could possibly have been prevented.

The team recommends that evaluation of the earthquake hazard of structures built under old building codes should begin immediately. This is particularly important for critical public buildings. They cite the collapsed San Fernando Veterans Administration Hospital buildings which were built before the existence of earthquake requirements. Critical public

buildings should be scheduled for rehabilitation or removal. Design requirements of hospitals, emergency services such as fire and police, utilities, communications, transpor- occupancy buildings should reflect the importance of the facility and the degree of danger involved in its failure.

Four hospitals in the area of the earthquake were unable to function because of damage. Water, sewage, gas, and electric facilities were severely damaged in the San Fernando Valley as were bridges important as potential evacuation routes. Disrupted power and telephone switching equipment added to the seriousness of the situation.

Deformation and deflection, as well as strength, should be considered in earthquake-resistant design. This is illustrated by the horizontal and vertical movements which caused bridge girders to move off their supporting abutments and piers. Ground displacements must be studied carefully to determine appropriate magnitudes of movement which should be accounted for in design.

Hazards of falling light fixtures, emergency lights, suspended ceilings and other overhead objects should also be given engineering consideration.

It also calls for more adequate tying together of units where large openings in walls are provided for garages or entranceways as this was found to be a particular weak spot by the surveyors. Chimneys, too, should be adequately reinforced and anchored to the main structure. The report also calls for the development of improved methods for supporting mobile homes.

The adequacy of present design requirements for the seismic design of dams should be reviewed, says the report, citing the near-failure of the Lower San Fernando Dam located above a densely populated residential area. All existing dams located close to a dense population should be examined for strength and stability due to ground faulting and acceleration.

Tipped stair tower at the end of the Olive View Hospital north wing. The towers on the other three wings toppled over.

The report recommends flexible joints and automatic cut-off valves to forestall seepage of water and sewage into gas lines which may fracture during severe ground movements. Proper anchorage of heavy electrical equipment to structural elemen s of a building is essential.

Design of elevator systems should be reviewed to insure their operation after a disaster. During the San Fernando earthquake, many elevators were put out of commission. Had the quake occurred during hours of heavy use instead of 6 a.m., lives would have been endangered. Had fires occurred, the passengers of immobile elevators almost surely would have died.

The report concludes that an expanded and improved seismograph network should be installed in public buildings in earthquake-prone regions throughout the United States. Information provided by the strong-motion seismograph is the single best source of scientific data that can be used in post-earthquake studies of structure performance.

[1] Engineering Aspects of the 1971 San Fernando Earthquake, NBS Building Science Series No. 40 (SD Catalog No. C13.29:40), may be purchased for $3 a copy from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

SOVIET METROLOGY TEAM VISITS NBS

During the latter half of February 1972, a four-man team of Soviet measurements experts spent 4 days in Gaithersburg and 2 in Boulder viewing Bureau facilities and activities. This coming May a Bureau/industry team will make a reciprocal visit to Russian metrological laboratories. This is the second such exchange between the two countries, the first having taken place in 1963-64. Such reciprocal arrangements increase Soviet-American cooperation in the field of precision measurement, and develop better mutual understanding.

It was the consensus of hosts and guests that closer cooperation between Russian and American standards laboratories is both possible and desirable, and areas mentioned for such cooperation included the following:

1. Determination of fundamental constants
2. Intercomparison of standards, coordinated through the International Bureau of Weights and Measures
3. The general field of ionizing radiation
4. Comparison of length, angle, and similar measurements
5. Certification methods
6. Industrial standard reference materials
7. Interchange of personnel
8. Interchange of publications.

The Soviet delegation was headed by Dr. Boris M. Isayev, a nuclear physicist and Vice Chairman of the State Committee on Standards, Measures, and Measuring Instruments. The Committee, which has the status of a ministry, maintains nine metrological institutes and 350 calibration and testing laboratories. It is responsible for uniformity of measurements and compliance with engineering standards, which are mandatory in the Soviet Union, and has broad authority to develop and enforce product quality standards.

Dr. Isayev is also the Soviet representative on the International Committee of Weights and Measures (CIPM), where his American counterpart is NBS Director Lewis M. Branscomb.

Other members of the Soviet team were Dr. G. P. Zedgenidze, Director, Tbilisi Institute of Metrology; Dr. Yu. A. Vdovin, Director, Sverdlovsk Institute of Metrology; and Dr. Yu. A. Atanov, Chief, High Pressure Section, All Union Research Institute of Measurements.

Dr. Zedgenidze is the author of a book on applications of mathematics to metrology, and the institute he heads does a great deal of work on the application of cybernetics, mathematics, computational techniques, and automation to metrology.

The institute Dr. Vdovin heads serves the Ural region, with its highly developed mining and smelting industries. Areas of concern include standard reference samples, techniques for determining the composition of substances, and measurement of high temperatures and large electric currents.

Dr. Atanov, who speaks fluent English, was here in a dual capacity: to investigate NBS work in the field of high-pressure measurements, and to assist in interpreting for the Soviet team. This is his third visit to the Bureau.

The visitors were guests of the NBS Institute for Basic Standards, headed by Dr. Ernest Ambler, and NBS Director Emeritus Allen V. Astin acted as the official host for NBS. All arrangements, which included laboratory visits, intensive program discussions, and social affairs, were made by Dr. Barry N. Taylor, Chief of the NBS Absolute Electrical Measurements Section.

An overview of NBS by Dr. Branscomb began the sessions, which concentrated on IBS, but included briefings and laboratory visits to the Institute for Materials Research, the Institute for Applied Technology, and the Center for Computer Sciences and Technology. Team members also visited two manufacturers of high precision equipment—Weinschel Engineering Company of Gaithersburg, Md., and Leeds and Northrup Company of North Wales, Pa.

Facilities viewed at Boulder included time and frequency, electromagnetics, quantum electronics, and cryogenics laboratories. The guests also inspected Radio Station WWV at Fort Collins, Colo.

Dr. Isayev noted that the Soviet Union and the United States have many similar problems in the field of precision measurement which personnel interchanges could help to solve. Visits of less than 3 months would be appropriate for prearranged tasks, but for research, periods of up to 1 year would be needed.

The concept of voluntary standards was the subject of considerable discussion, as voluntary standards are unknown in the U.S.S.R. The visitors were particularly interested in how such standards

Continued on page 115

ABSOLUTE MEASUREMENT OF VISCOSITY

NBS COMPARES MEASUREMENTS BY NEW INSTRUMENTS

Robert Penn examines interference fringes under sodium light to verify uniformity of dimensions before using channel to make an absolute viscosity measurement. The viscosity of the liquid flowing through this precisely dimensioned channel will be known from the pressure differential between pressure taps and from the temperature, which is carefully stabilized in a water bath.

Years ago, Bureau scientists recognized that systematic errors in absolute measurements of viscosity could be several times as great as measurement reproducibility, 0.1 percent. They therefore recommended that at least two independent absolute methods of measuring viscosity be developed for appraising the total uncertainty of viscosity measurements.

In response, two new absolute viscometers were devised at the Bureau's Institute for Basic Standards. They were subsequently used to measure the viscosity of liquids and the results were compared with each other and with those from earlier measurements.[1,2,3] A systematic difference of 0.5 percent, five times the total known uncertainties for either method, was found between the two measurements. No change in the accepted value for the viscosity of water, used in the calibration of relative viscometers, is suggested by these results. But whenever a "true" value of viscosity is required, the uncertainty assigned should be taken as no less than ±0.25 percent.

LONG-TERM VISCOSITY PROGRAM

The currently accepted value for the viscosity of water, 1.002 cP (centipoise = 10^{-3} pascal second) at 20 °C, was recommended in 1952 by J. F. Swindells, J. R. Coe, Jr., and T. B. Godfrey,[4] after NBS research over a period of 20 years. Later, in 1957, Elliot A. Kearsley pointed out that any unknown systematic error affecting contemporary measurements (most made in capillary viscometers) could be discovered only by comparisons with measurements made by other methods. NBS scientists considered alternative measurement schemes for appraising systematic errors. Two new instruments were devised and built as a result of this effort.

VISCOSITY MEASUREMENT FROM CHANNEL FLOW

The primary shortcoming of the capillary viscometer for absolute measurements is that the bore of the capillary tube is not uniform. This problem was overcome by Dr. Robert W. Penn and Dr. Kearsley, who assembled a flow channel from components of precisely known dimensions.[3] The channel was formed by clamping together two 2-cm-diameter stainless-steel rods and a 2-cm-thick glass flat to produce a tri-cusped channel 1 metre long. Four pressure-measurement taps were drilled through the glass flat in a corner of the channel cross section, a region of low velocity, a location minimizing disturbance of the flow.

Flow control valves allow oil (a commercial grade of di(2-ethylhexyl) sebacate) to flow through the channel at a controlled rate in either direction from a thermostatted standpipe, which maintains a constant-pressure head. A solenoid-operated diverter in the stream of oil exiting the channel permits accurately timed samples to be col-

Elliot Kearsley inspects height of liquid inside a hollow sphere that, when excited, will become a rotational pendulum, turning in first one direction and then the other. It can be used to make absolute viscosity measurements, the viscosity of the sample liquid being calculated from observed parameters, including the period of oscillation.

lected. A fused-quartz Bourdon-tube pressure gage can be connected by valves to any one of the four pressure taps or to a dead-weight piston gage for calibration.

The apparatus was used by measuring pressure differences and flow rate and substituting in an equation for kinematic viscosity that includes a geometrical constant for the channel. (The upper and lower bounds of this constant were calculated on a digital computer.) All measurements were related directly to the national standards of mass, length, and time and to the International Practical Temperature Scale of 1948.

The channel flow measurements yielded viscosity values corresponding to a viscosity of water of 1.001 cP at 20 °C. The estimated total systematic error is 0.13 percent. All measurements were within ±0.03 percent of their mean and the coefficient of variation of the measurements was 0.02 percent.

VISCOSITY MEASUREMENT BY THE TORSIONAL PENDULUM

The second new approach to absolute viscosity measurement, developed by Hobart S. White and Dr. Kearsley,[2] makes use of a rotationally oscillating torsional pendulum, a hollow sphere hanging by a wire and filled with the fluid whose viscosity is to be measured. When the sphere is rotated slightly and released it oscillates through decreasing angular excursions. The viscosity of the fluid can be calculated from either the period of the motion or the decrement of its amplitude. Although the decrement had been used in most measurements to date, White and Kearsley took advantage of modern techniques of accurate time measurement to measure period instead.

Many practical problems had to be solved in order to obtain a pendulum offering high reproducibility and accuracy of measurements. Ultimately a seamless nickel sphere was electroplated on an aluminum form that had been fitted with nickel hubs. The aluminum was then dissolved by a caustic solution pumped through the sphere via the hubs and the exterior of the nickel sphere was then ground to a thickness of 0.085 inch and a nominal diameter of 10 cm. One hub was closed and a hollow stem with a sight glass bearing a fiducial line was inserted in the upper hub. The sphere was filled through the sight glass and placed in an oil bath thermostatted to 25.00 ±0.01 °C until thermal equilibrium was attained.

The sphere was used within a thermostatted chamber in which the air pressure was reduced to less than 0.2 mm of mercury and the temperature held at 25.00 °C. The rest-position crossings were sensed photoelectrically and the time intervals measured by an electronic counter calibrated against an NBS standard frequency.

The oscillating sphere measurements yielded values corresponding to a viscosity of water of 1.006 cP at 20 °C. The total systematic error that could be identified was 0.07 percent and measurement variability was even less.

COMPARISON OF MEASUREMENTS

The values for the viscosity of the two fluids measured by the oscillating pendulum and by the channel were compared and the two fluids were compared directly by means of a relative viscometer. The ratio for the compared values differs by 0.5 percent from the ratio found by use of the relative viscometer. This difference is 10 times the coefficient of variation of any of the measurements and about five times the estimate of maximum systematic error for either absolute measurement. Obviously, unidentified systematic error is present in one or both of the absolute measurement methods.

An evaluation of the recent and earlier results was carried out by Dr. Robert S. Marvin.[1] His findings do not suggest a change in the value of 1.002 cP now used for the viscosity of water at 20 °C in the calibration of relative viscometers or in the uncertainty applicable in the comparison of relative measurements. They do suggest that if a "true" value of viscosity is required, measurements from instruments calibrated in terms of the viscosity of water should be assigned an uncertainty of no less than ±0.25 percent, 2 1/2 times the figure formerly assumed.

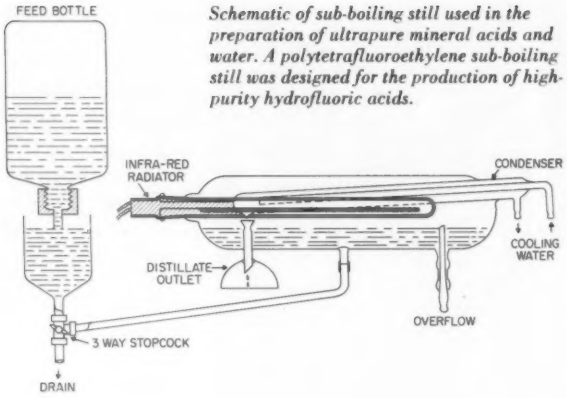
[1] Marvin, R. S., The accuracy of viscosity measurements of liquids, J. Res. Nat. Bur. Stand. (U.S.), **75A**, No. 6 (Nov.-Dec. 1971), SD Catalog No. C13.22/sec.A:75.

[2] White, H. S., and Kearsley, E. A., An absolute determination of viscosity using a torsional pendulum, J. Res. Nat. Bur. Stand. (U.S.), **75A**, No. 6 (Nov.-Dec. 1971).

[3] Penn, R. W., and Kearsley, E. A., An absolute determination of viscosity using channel flow, J. Res. Nat. Bur. Stand. (U.S.), **75A**, No. 6 (Nov.-Dec. 1971).

[4] Swindells, J. F., Coe, J. R., Jr., and Godfrey, T. B., Absolute viscosity of water at 20 °C, J. Res. Nat. Bur. Stand. (U.S.), **48**, No. 1 (Jan. 1952).

PREPARING ULTRAPURE REAGENTS



Schematic of sub-boiling still used in the preparation of ultrapure mineral acids and water. A polytetrafluoroethylene sub-boiling still was designed for the production of high-purity hydrofluoric acids.

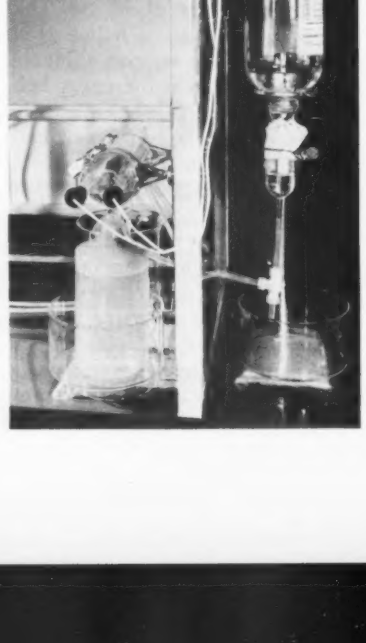
A sub-boiling distillation technique is being used at the Bureau to produce ultrapure reagents for use in trace metal analyses. Scientists in the Analytical Chemistry Division have used the technique to remove metallic or cationic impurities from inorganic acids and water.[1] In most cases, analysis of the purified reagents showed an impurity of less than one part per billion for each element determined.

Because trace elements play an important role in many biological processes and are of increasing concern to environmentalists, their accurate analysis is of major importance. To obtain maximum information from samples it is necessary that the reagent blank be less than a few percent of the amount being measured. Therefore, the accurate determination of an element at the 1 part per million (ppm) level, a common requirement, depends on the availability of reagents containing less than 1 part per billion (ppb) of that element.

In sub-boiling distillation, infrared radiators vaporize the surface without boiling the liquid in the vaporization compartment. The vapor is condensed on a tapered cold finger and distillate collected in a suitable container. Sub-boiling quartz stills, similar to commercial stills used in the production of high-purity water, were installed at NBS for the production of hydrochloric, nitric, perchloric, and sulfuric acids as well as water. For the production of high-purity hydrofluoric acid, a polytetrafluoroethylene (TFE) sub-boiling still was designed and constructed.

Efficient purification by the still only partially solves the problem of producing and distributing pure acids. To insure a high-quality product, air-borne particulate and container contamination must also be minimized. Air-borne particulate contamination was virtually eliminated by enclosing the still and distillate containers in a Class 100 clean air chamber. Fluorinated ethylene propylene (FEP) bottles, thoroughly cleaned with nitric and hydrochloric acids, are used as containers for the purified acids and high-purity quartz bottles are used for water.

Quartz still utilized in the sub-boiling distillation reagents. Samples so purified contain impurities of less than 1 ppb of each element determined.



Creeping of the unpurified liquid and entrainment of particulates formed during bubble rupture in the vapor stream contaminate the distillate in conventional distillation. Since no bubbles are formed in sub-boiling distillation, the entrainment problem is completely eliminated; the position of the cold finger minimizes creeping of the impure liquid. The still is extremely effective in the separation of impurities of low vapor pressure such as metal ions, but it offers little purification from contaminants of high vapor pressure such as organic matter or many of the anions.

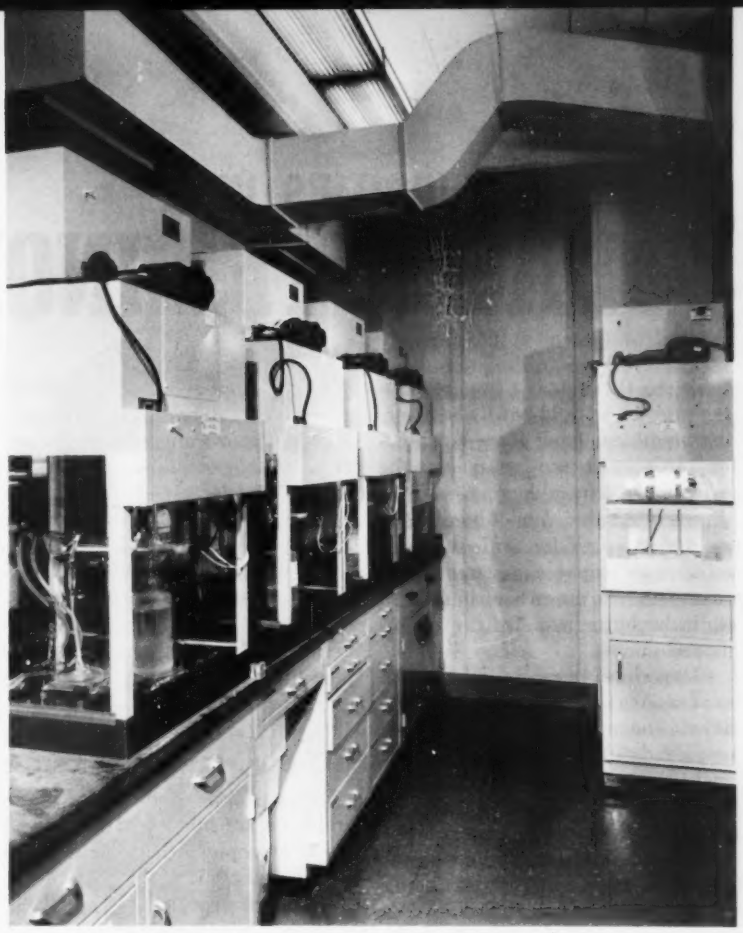
To evaluate the purity of the acids and water produced by this process, an analytical method based on isotope-dilution, spark-source

mass spectrometry was developed. The method has limits of detection below 0.1 ppb for impurity elements. Seventeen elements were determined simultaneously in each of the high-purity acids and water produced by sub-boiling distillation and in each of the ACS grade acids used as starting materials. Emission spectrography, the most commonly used method of analysis, has detection limits well above 1 ppb for most elements.

Analysis by isotope dilution is possible for elements that have two or more naturally occurring isotopes. A highly enriched isotope (spike) for each element to be determined was added to the high-purity reagents. After equilibration of the spikes with the natural impurity elements in the acids, the sample was evaporated and the concentrate placed on the tips of a pair of high-purity gold wires (NBS Standard Reference Material 685). The spiked impurities were sparked off the surface of the wires in the spark-source mass spectrometer and their mass spectrum recorded photographically. The altered isotopic ratio of each element was measured from the photoplate with a densitometer. The concentration of each impurity element in the acid is computed from the amount the natural isotopic ratio was altered by the addition of a known amount of spike of a different isotopic composition. Monoisotopic sodium was estimated by comparing its absolute intensity to that of potassium.

This facility for producing ultrapure reagents has been operating routinely for over 6 months and a number of scientists within NBS and in other government agencies are using these five special acids and the high-purity water. Persons interested in these high-purity reagents should contact Thomas J. Murphy of the Analytical Chemistry Division.

[1] Kuehner, E. C., Alvarez, R., Paulsen, P. J., and Murphy, T. J., The production and analysis of special high-purity acids purified by sub-boiling distillation, to be published.



Laboratory used for production of high-purity acids. The still and distillate containers are enclosed in Class 100 clean air chambers to minimize particulate contamination.

Analysis of Acids and Water Purified by Sub-Boiling Distillation
Concentration in ppb (ng/g)[a]

Impurity element	H_2O	HCl	HNO_3	$HClO_4$	H_2SO_4	HF
Ag	0.002	0.03	0.1	0.1	0.3	0.05
Ba	0.01	0.04	0.01	0.1	0.3	0.1
Ca	0.08	0.06	0.2	0.2	2	5
Cd	0.005	0.02	0.01	0.05	0.3	0.03
Cr	0.02	0.3	0.05	9	0.2	5
Cu	0.01	0.1	0.04	0.1	0.2	0.2
Fe	0.05	3	0.3	2	7	0.6
In	—	0.01	0.01	—	—	—
K	0.09	0.5	0.2	0.6	4	1
Mg	0.09	0.6	0.1	0.2	2	2
Na	0.06	1	1	2	9	2
Ni	0.02	0.2	0.05	0.5	0.2	0.3
Pb	0.003	0.07	0.02	0.2	0.6	0.05
Se	—	—	0.09	—	—	—
Sn	0.02	0.05	0.01	0.3	0.2	0.05
Sr	0.002	0.01	0.01	0.02	0.3	0.1
Te	0.004	0.01	0.01	0.05	0.1	0.05
Tl	0.01	0.01	—	0.1	0.1	0.1
Zn	0.04	0.2	0.04	0.1	0.5	0.2
Total impurities (ppb)	0.52	6.2	2.3	16	27	17

[a] Concentrations below 0.1 ppb are maximum values.

CHANGING PRIORITIES IN TODAY'S TECHNOLOGY*

To say that this is a time of shifting priorities would hardly be bringing breathless news from Washington. In science and technology, the evidence of the changing order of things is graphic. Undoubtedly, the most alarming indicator is the large number of capable engineers and scientists who have been forced to walk the bitter world of the unemployed.

Meanwhile, many in the academic community in a sense have been rendered underemployed. This is the situation that prevails when you can't get adequate funding for your research.

And yet—in terms of challenge and opportunity—this is a time of plenty. Grave and confounding problems literally engulf mankind. Engineering and science can help solve these problems, but first we must understand their nature and dimensions. I suppose that one of the most significant things that can be said about these problems is that they do not lend themselves to single-discipline solutions.

The problems I refer to are complex and civilian-oriented. They are problems which arise from the increased aspirations of our society, from the increased recognition of need for constraints—that is, generate more electrical energy but generate it cleanly. But by all indications, these problems represent the wave of the future—and that future is now. Scientific applications have always been complicated. And increasingly, we are called upon to demonstrate not only the utility of an application but also to justify it in terms of after-effects or side-effects; to see it in a context of a total societal impact.

Great emphasis is being placed on such problems as inadequate housing, poor transportation, poverty, abuse of resources, occupational dislocation, deterioration of the city, environmental pollution, and a growth in crime. It is by capturing opportunities in such problem areas as these that the temporary decline of technology due to pullbacks in aerospace and the military might possibly be offset—and perhaps more than offset.

SOCIAL AND TECHNICAL PROBLEMS

The characteristics of these problems are many and varied and are to a preponderant extent social as well as technical.

No doubt many of you recall the Summer Study on Science and Urban Development held at Woods Hole, Mass., in June of 1966. This conference, sponsored by HUD and the Office of Science and Technology in the President's Executive Office and attended by some 50 nongovernment scientists and urban specialists along with staff members from several Federal agencies, culminated in an optimistic report.

What is good problem-solving for outerspace is good for urban space, was the gist of that report. But the Woods Hole conferees added significantly:

> Creating a safe, happy city is a greater challenge than a trip to the moon because urban housing is more complex than a rocket and the city is subject to more perturbations than the moon. Its ever-changing problems, nevertheless, can be attacked in the same logical way we have gone about exploring the universe.

WHAT CONFIGURATION?

It is essential that our assaults on multi-dimensional problems be interdisciplinary.

But how do you design the interdisciplinary team? Who creates the team? The prospective building owner in selecting an architect effectively selects the chief influence on the architecture of the building. So too is the person or entity naming the team disciplines the principal influence on the direction of the interdisciplinary effort.

In short, what configuration should the desired interdisciplinary effort assume? And how should industry, the university, and Government collaborate in this regard?

As if this question were not tough enough, we have to reckon with the milieu in which the team is to function. We have to face realities such as politics and vested interests. To fail to chart a course which recognizes these forces is to waste much labor.[1]

IDIOSYNCRATIC HANGUPS

Every problem calls for careful analysis of the "problem system"—examination of all technological, institutional, sociological and political aspects and their interaction with one another. Such an analysis may well show that every problem area has its own hangups, its own idiosyncratic nature. In environmental pollution, for example, we have seen the development of an adversary situation between industry and regulatory agency which threatens to dominate

*Excerpts from a talk by F. Karl Willenbrock Director, NBS Institute for Applied Technology, presented June 17, 1971, to the Conference, "Challenges and Opportunities of the 1970's," University of California, Berkeley.

the technical side of the problem. Such diverse areas as health services, fire and consumer safety, housing, transportation, and crime undoubtedly require different solutions. We find in each of these areas idiosyncratic barriers to innovation and development.

ONE HOPEFUL AREA—HOUSING

A good analysis, on the other hand, should bear beneficient results. And one of the present programs of the NBS Building Research Division of the Institute for Applied Technology, I think—and hope—is an example of the right way to ferret out and deal with complexities. The problem deals with the goal, on which the Congress and Executive Branch are agreed, that 26 million new and rehabilitated housing units be constructed within a 10-year period. It is well-established that this goal will not be met if we are constrained to use present building techniques. But traditional techniques continue—largely because of the building regulatory system that is symbolized by a document which most of us have encountered at one time or other—the building code.

There are 6,000 differing building codes in force in the United States. This fragmented system of disparate codes is incapable of speedy evaluation and acceptance of technological innovation. In effect, there is no single, cohesive market for conventional products or systems—much less for innovative ones. Industry is discouraged from research and development investments, and in the end, it is the consumer who suffers.

It would be easy to wring our hands at this point and say, "Isn't it awful." But there is a process well underway to solve this problem and in which I am quite optimistic. My optimism was strongly reinforced when the White House asked NBS to insert an extra $1 million in the President's budget for 1972 to support the process.

Specimen of a honeycomb sandwich panel is performance tested to determine the strength of the structural adhesive used in its construction.

The solution—if it is not too early to use this term—involves two innovations, one conceptual and the other institutional.

The conceptual change is to shift the basis of building codes toward a performance basis rather than a prescription basis. Instead of a code specifying how a wall should be made, it describes such characteristics as its load-bearing capacity, its acoustic attenuation, and its fire resistance.

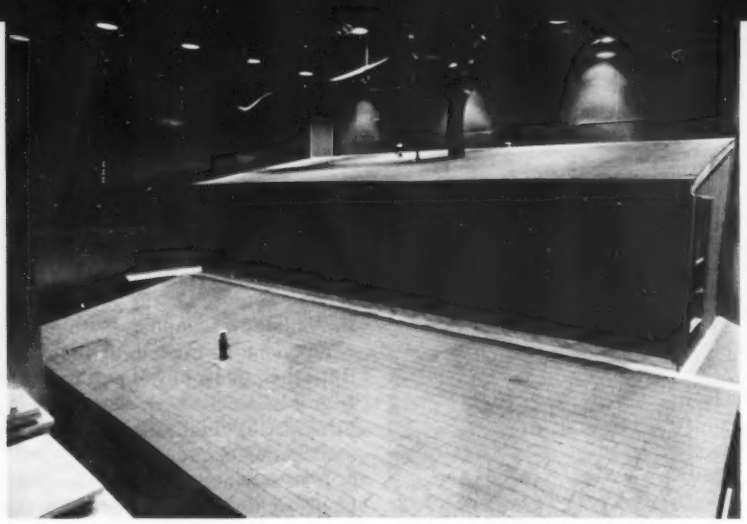
The performance approach demands a statement of performance in terms of function. Let me quote Dr. James R. Wright, Chief of the Building Research Division, who in writing in a recent issue of *Scientific American* magazine[2] explained: "Since buildings serve people, function is defined by the attributes necessary to satisfy human requirements. In this way the builder or supplier of a building component is invited to innovate. (But) the philosophy of performance begins and ends with—and puts its principal emphasis upon—the satisfaction of human needs."

Just having a new conceptual basis for building codes does not produce new and exciting technological advances in the construction industry. An essential ingredient is a unitary, mass market. This in turn requires compatibility among codes. To accomplish this result, a national association of State building code officials was formed a few years ago with NBS serving as its secretariat. You may recall that building regulatory authority in the United States resides at the State and local government level. The young organization—the National Conference of States on Building Codes and Standards—seeks to bring about greater intrastate code uniformity and, principally through reciprocal arrangements, interstate uniformity as well. Also the Conference is working toward a performance approach in its codes and standards.

These efforts are going forward at a good rate. Our secretariat assistance at NBS includes strong technical back-up.

Included in the plans of the Conference is a technique for developing a system for testing factory-built housing for compliance with performance criteria acceptable to the States. A test laboratory evaluation system is under active development, whereby test results from accredited laboratories can be accepted by regulatory officials in any State.

Let's assume for a moment that the work of the Conference removes regulatory constraints, and that the



Overhead view of a complete living unit undergoing performance testing in the NBS environmental chamber.

Nation's technological capability is turned loose on the building problems. Can we expect dramatic results?

The most zealous advocates of the performance approach promise significant cost/benefit advances. The most ardent advocates of a cohesive market draw hopeful pictures of volume production and resultant economies of scale.

Performance-based standards and a cohesive market both inspire industrial interest in building product development. Performance requirements also stimulate interest — R&D — in innovative products and industrialized building systems; that is, to produce houses somewhat as the automobile industry produces cars. The construction industry at present is essentially a handcraft industry.

Yet, if the industry were freed on both conceptual and institutional counts, techniques in building in the near future will change in response to improvements in the state-of-the-art. What is needed is time for advances in research and applied technology. The important thing is, the way would be open to expand our capability to use advanced techniques.

ROLE OF NBS IN BUILDING

The NBS Building Research Divison is much involved in structural mechanics, acoustics, thermal studies, plumbing engineering, fire safety, materials durability, building economics, and so on. Our researchers have identified many areas into which they feel we should move with vigor — areas such as adhesives for elements of residential construction, criteria for built-in electrical joints and components, control of air movement in buildings, strength and durability of structures for earthquake loading, integration of electrical systems with building envelopes, criteria for smoke detection systems, indoor air quality, criteria for the functional effectiveness of innovative fluid flow systems, economic evaluation of heating-cooling systems, and economic aspects of floor covering, just to name a few.

Our staff also proposes additional work bearing directly on the human condition — such as the development and refinement of human response criteria for acoustic environments in buildings.

Robert Sommer, Chairman of the Psychology Department of the University of California's Davis campus, in his book *Personal Space*, noted that the "form follows function" dictum of architecture was useful in purging ornamentation, but he observed:

> Yet it is curious that most of the concern with functionalism has been focused upon form rather than function. It is as if the structure itself — harmony with the site, the integrity of the materials, the cohesiveness of the separate units — has become the function. Relatively little emphasis is placed on the activities taking place inside the structure.

THE UNIVERSITY'S ROLE IN HOUSING

As a matter of fact, it is in the softer areas, the behavioral and social sciences, that the building performance approach might appeal most directly to the university community. The appeal to the university involves additional factors as well. Not the least of these resides in the student component of the university community, a component which is conspicuous in its demand for an educational experience that is, as the students are wont to say, relevant. It seems to me that it is difficult to find a more relevant problem than getting buildings to fit people.

Let me assure you that we are dead serious about this matter of meeting human needs. We are not seeking mere hardware substitution — although widening the range of candidate solutions to hardware problems has distinct advantages. But we hope to transcend this objective; we hope to influence the creation of buildings which truly accomodate function and human physiological and psychological needs. Who knows, we may one day have homes which not only shelter and accomodate but which regenerate!

All of this may sound very blue-skyish, but performance is very viable; it is the track on which a substantial record is in the process of being built. A very considerable investment has been made in this approach by NBS in its work on Operation BREAKTHROUGH for the Department of Housing and Urban Development.

CRITERIA FOR OPERATION BREAKTHROUGH

BREAKTHROUGH is aimed at doing what its name implies—at breaking through constraints on the creation of decent housing in adequate production volume. Through this program, HUD is seeking to stimulate the development of industrialized "systems"—usually modular box or panel arrangements of prebuilt house components.

But the systems the program is spurring are innovative and thus do not lend themselves to evaluation for health and safety characteristics through conventional codes. So HUD asked NBS to generate performance criteria for the design and evaluation of BREAKTHROUGH housing. Twenty-two housing systems selected under the program, and now in the prototype construction phase, are being evaluated.

Since the housing systems have not stood the test of the marketplace and time, the NBS criteria also set minimum levels for livability and durability. And the criteria try to exploit the latest technology—smoke detectors for multifamily BREAKTHROUGH housing, as an example.

Just getting underway in our Building Research Division is our Project Feedback in which the prototype BREAKTHROUGH housing will be evaluated from the point of view of its occupants.

The performance approach in the building field has barely taken root—the field is wide open and our need for research will continue to increase as we glimpse those areas where we don't have nearly enough knowledge. But the BREAKTHROUGH criteria represent a beginning.

If the house is seen as a component of a system of human settlement, the range of possible solutions to what is called the "housing problem" expands. Is it possible to achieve greater reductions in housing costs through demographic perturbation than through technological innovation? In other words, if most of us are impacted in urban areas, and if this concentration drives up the cost of urban and suburban land, would a lessening of this impacting tend to level out escalating land prices? Certainly those families who were enticed from urban locations would doubtless appreciate the benefit of lower land costs.

Street wisdom says the people will go where the jobs are. Well, maybe something could be done to coax industry from impacted areas. Glib wisdom says that people want to go "where the action is." I'm not so sure of this.

If my memory serves, a Gallup Poll of several years ago seeking to determine people's settlement preferences, found that the majority of Americans prefer rural or small-town America.

In any event, the house can be seen as a component of a settlement system, and the settlement system in turn as part of a larger life-support system composed of occupational, educational, recreational, and other aspects.

All over this country we can find people living happily in houses they would not label as good houses, but houses which happen to be located in what their occupants consider to be advantageous areas. I'm not suggesting that we build bad houses; I'm simply saying that we should understand the problem we are trying to solve and then solve it in a systems way, which may mean giving people the widest possible range of choice.

TRANSLATION AND TRANSFER

However, the task of translating real-world problems into appropriate topics for university-based research efforts is not a trivial one. An in-depth understanding of the real-world problem is needed to be able to identify the knowledge gap which needs to be plugged. Needed is an appreciation for the university's mode and strengths. There are a number of "long-shot" ideas which need to be analyzed in the hope that a few may work out, or more likely, that better ideas will be stimulated as the problems are understood in greater depth.

CIVILIAN-ORIENTED RESEARCH

In the period when DOD, NASA, AEC, and NSF funding effectively absorbed nearly all the extant university research capability, the job of converting research results into useful technology was at best a most difficult one.

But now let us consider a civilian-oriented research project. It is not only possible but most desirable to have a close coupling between the researcher and the individual who is involved with operational problems. It is probable that such research should not be directed toward product development which is traditionally an area in which industrial R&D has been most effective. But there is much research to be done which relates to the development of a more fundamental understanding of complex situations of a socio-technical nature. It could well be that the problem-solving process may require a different mode of operation than having Federal dollars going to an organization in response to a proposal for a University with an end-product of a report whose technical quality is approved in a peer-evaluation process.

The need may be for a continuing interaction between those who approach the problem from a technical point of view and those involved with the socio-political scene. This latter process is not a type of censorship but rather a reflection of that fact that the problems needing solution have a social and political context as well as a

Continued on page 119

DYNAMIC PRESSURE TRANSDUCER CALIBRATOR

HYDRAULIC METHOD IS EASILY TIED TO STATIC CALIBRATION

A technique for dynamically calibrating pressure tranducers with greatly improved accuracy has been developed in the instrumentation laboratories of the Bureau's Institute for Applied Technology. Physicist John Hilten, engineer Paul Lederer, and aide John Sethian devised a dynamic calibration method that is simple in the extreme. The only special equipment required is an easily fabricated tube that is mounted on the table of a shaker. In laboratory tests at amplitudes up to 20 psi and at frequencies from 15 to 2000 Hz, the method has yielded agreement between static and dynamic calibrations of ±0.1 percent. The new calibrator is expected to have particular significance in calibrating pressure transducers for biomedical applications.[1]

CALIBRATION OF PRESSURE TRANSDUCERS

Pressure transducers have been in existence for over 30 years, but until now could not always be adequately calibrated dynamically. Static calibrations could be performed with acceptable accuracy, but use of the transducer for dynamic measurements in the vast majority of cases was based on the unwarranted assumption that a static calibration of the reference transducer sanctioned its use for dynamic applications.

The increasing utilization, in recent years, of electromechanical transducers for measuring pressure in fluids created the need for an improved calibration capability. This need was recognized by the InterAgency Transducer Project, which for years supported a continuing transducer characterization and calibration program at the Bureau. The Naval Air Systems Command, one of the participants in the InterAgency project, supported the development of a dynamic method of pressure calibration at the Bureau.

NEW DYNAMIC METHOD

The NBS method for dynamically calibrating pressure transducers requires only one piece of special equipment—a rigid, open-topped container for vertical mounting on the table of a shaker. The calibrator used at NBS is composed of a 1-inch (inside diameter) brass tube soldered into a hole counterbored in a square brass block. The block is threaded at the side to receive the transducer being calibrated (with diaphragm vertical to minimize the effect of vibration on the transducer) and on the bottom for attachment to the shaker table.

The calibrator is used by mounting it atop the shaker table, installing the test transducer, and filling the tube with water (or any liquid of known density) to the desired height. The pressure at the center of the diaphragm can be readily computed from fundamental physical parameters—the height of the liquid and its density—or an accurately known gas pressure can be applied to the column measured.

The accuracy of the static calibration is transferred to the dynamic calibration by adjusting the shaker input to the desired acceleration level with the aid of a precision accelerometer. Use of the accelerometer is made necessary by the fact that the water gives no reliable indication when zero pressure is reached during part of the cycle. The precision accelerometer in turn can be calibrated, both statically and dynamically, by well-established fundamental methods. The technique is therefore not limited to a peak-to-peak pressure of twice the static head of the liquid, which is attained at an acceleration level of $\pm 1\ g$ (the value of gravitational acceleration), but has been extended to reach levels of $\pm 29\ g$ in these experiments at NBS.

TESTING DYNAMIC METHOD

The new system was tested by calibrating three flush-diaphragm pressure transducers of different ranges, one a bonded strain gage type and the others semiconductor types. A three-point static calibration was performed on each at pressures corresponding to 40, 0, and −40 inches of water (obtained by control of air pressure) before the dynamic calibration to correlate the static and dynamic calibrations and to determine instrument stability. The dynamic calibrations were performed at frequencies from 15 to 2000 Hz and at accelerations from ± 1 to $\pm 29\ g$. The shaker used was a commercial device having a range of 5 Hz to 10 kHz and a force rating of 300 pounds (1330 newtons). The outputs of a reference accelerometer and of the pressure transducer were read to ±0.1 percent on an rms

differential voltmeter and the pressure transducer output distortion was checked with a distortion meter.

The transducer output at each dynamic calibration point was compared with the level expected by extrapolation from the static calibrations. The two were in agreement within ±0.1 percent for one transducer, within ±0.3 percent for another, and 1.6 percent disparate for the third (possibly due to a poor signal-to-noise ratio, inherent in this transducer system).

Linearity of transducer response was given as the maximum deviation of the response ratio (volts output/input pressure to the transducer) at each dynamic calibration point from the average at all calibration points. The deviation values of 0.5, 0.4, and 0.3 percent found for the three transducers for a variety of frequencies (to 300 Hz) and acceleration levels are thoroughly acceptable linearity figures.

The resonant frequency of the transducer-water column system also was studied, since measurement stability and accuracy cannot be obtained in the vicinity of a strong system resonance. A resonance of 1590 Hz was computed for the 9-inch water column alone and values of 1210, 1350, and 1410 Hz were measured for the three transducer-column systems tested. Also, distortion at several lower frequencies was found to be so great that these frequencies were avoided thereafter.

EFFECTS OF CHANGED PARAMETERS

The parameters that could affect calibrator performance were studied and their effects appraised. Some were computed, such as the increase in volume when the diaphragm is displaced by pressure and the slight bulging of the tube walls under pressure of the water column. Another parameter—absorbed gases—is prevented from affecting the calibration by degassing the liquid and calibrator in vacuum before use.

The consequence of changes in the height and diameter of the liquid column also were studied. Shorter (3- and 6-inch) columns of water produced the same response ratio as the 9-inch one at low frequencies and remained linear to higher frequencies because of their higher resonance frequency.

Liquids other than water also were used in the calibrator—glycerin, ethyl acetate, and oil—in an attempt to correlate known properties with performance in the device. Unfortunately the experimental values of resonant frequency for the glycerin and ethyl acetate did not correlate as well as values for water, as disparate values for their characteristics were found in the literature.

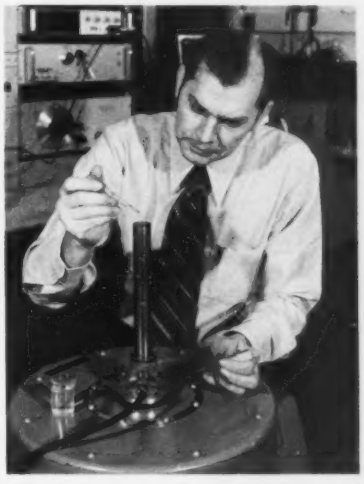
It was found that the Q (a figure of merit related to sharpness and amplitude of resonance peaks) of the calibrator was so high and the damping so low that the system resonances reduced the useful frequency range of the calibrator. The scientists sought to obtain a flatter frequency response by increasing the damping to 0.6 of critical damping.

They first increased damping by increasing the calibrator surface area, breaking up the original tube into smaller parallel tubes having a greater total wall area. This was done by packing the calibrator with several smaller tubes (1/2-, 1/4-, and 1/8-inch). They also experimented with more viscous liquids, succeeding in lowering the Q (143 with water) to 1.2 by using SAE 140-weight gear lubricant and breaking the calibrator cross section up with 48 1/8-inch tubes. This produced a damping that is 0.44 of critical damping, greatly enhancing the usefulness of the calibrator.

[1] Hilten, J. S., Lederer, P. S., and Sethian, J. D., A Simple Hydraulic Sinusoidal Pressure Calibrator, Nat. Bur. Stand. (U.S.), Tech. Note 720 (in press), available as SD Catalog No. C13.46:720 from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

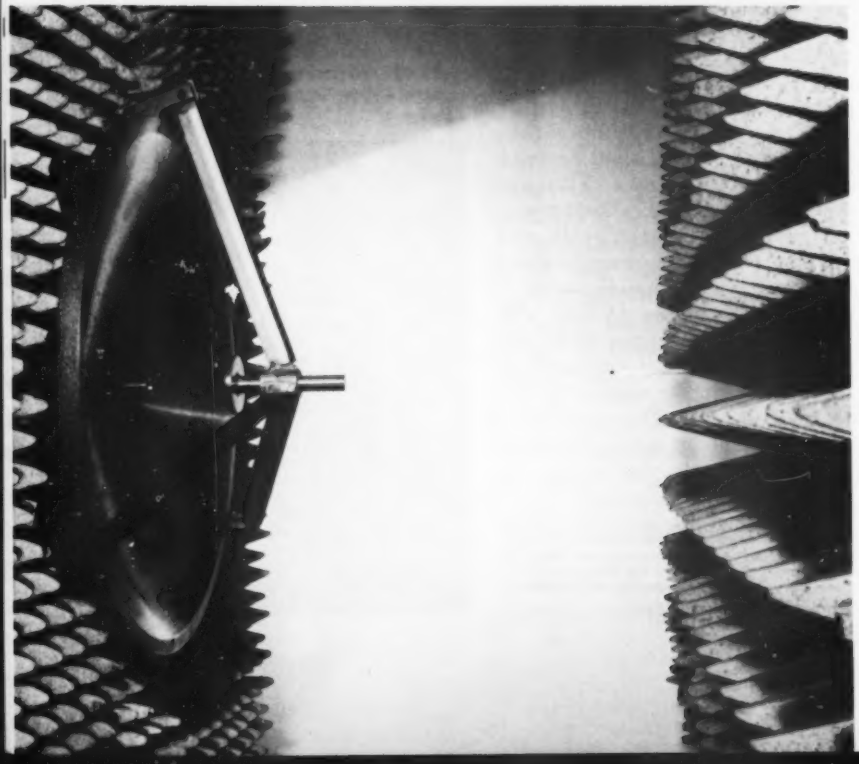
Paul Lederer mounts a dynamic pressure transducer calibrator on the table of a shaker—an electrodynamic vibrator. The pressure transducer at the base of the calibrator will then indicate the pressure of the 9 inches of water in the column. The static calibration pressures can be transferred to points on the dynamic calibration scale of 0 and 18 inches of water by adjusting the shaker amplitude for sinusoidal variations between these values.

John Hilten prepares a dynamic pressure transducer calibrator for use by adding water to obtain a 9-inch head at the center of the test transducer diaphragm (at end of wires). The calibrator and the water will be degassed before the calibrator is mounted on a shaker.



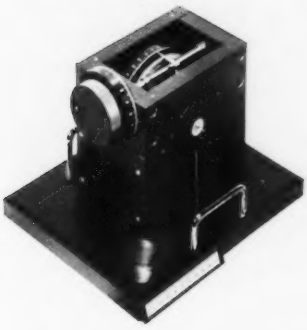
NBS Reference Noise Standard (center) operates between 50 and 75 GHz. It comprises a lossy resistive element, heated to 1000 °C, and is located in a platinum-rhodium alloy waveguide. Constant flow of temperature-controlled coolant is provided by console (right); resistive-element heating control and temperature measurement of standard provided by rack of equipment (left).

NBS INAUGURATES MILLIMETR CALIBRATION SERVICE



Millimetre waves are here to stay—at least that's the strong implication drawn from the Bureau's move into mm-wave calibration services. The Bureau announced the availability of interim services at their Boulder, Colo., laboratories, in February 1972. By extending its long-established microwave services into the 55- to 65-GHz millimetre-wave region, NBS fills a need that has existed since the early days of millimetre-wave research and exploration. They now have ready a millimetre-wave capability to measure power, attenuation, im-

Indoor Near-Field Scanning Range where probe (right) measures, point-by-point, amplitude and phase of field from antenna under test (left). Computer program massages data to yield on-axis antenna gain and far-field pattern.



Modified rotary-vane attenuator offers improved readout to 0.01 degree.

ETRE-WAVE

pedance, antenna gain, and noise and can calibrate devices needed to make such measurements. The services will be classified interim until the projected accuracies stated below are given final approval.

POWER

To measure power, NBS developed a microcalorimeter as a reference power standard plus a transfer method permitting bolometer-coupler units up to 20 dB to be calibrated to within ±2 to ±3 percent. Accurate in itself to within ±0.3 percent, the microcalorimeter provides the basis for establishing an absolute standard of power measurements in this frequency range. During operation the calorimeter is submerged in a water bath, the temperature of which is maintained to 10 microdegrees short term and 25 microdegrees long term.

ATTENUATION

To measure variable attenuators, a 30-MHz i-f substitution measurement system was developed to determine the attenuation difference to within ±0.05 dB per 10 dB in a range of 0 to 50 dB. A 30-MHz piston attenuator (waveguide below cutoff) serves as a reference attenuation standard. The system also measures fixed attenuators and insertion loss of variable attenuators to better than ±0.2 dB per 10 dB.

It is not uncommon for variable attenuators operating at these frequencies to be off by as much as 5 dB at a nominal dial setting of 50 dB. To circumvent this problem, NBS modified a pair of rotary-vane attenuators to yield an improved readout. One, for less critical applications, indicates the angular rotation of the center vane to 0.01 degree while the other indicates to the nearest 0.0005 degree. When electrically aligned, these attenuators provide maximum attenuation values between 65 and 90 dB and resolve difference attenuation values to 0.005 dB at these maximum settings.

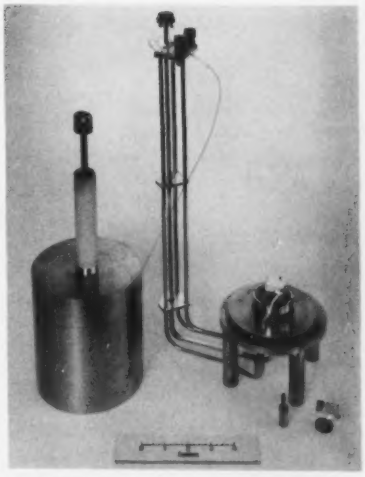
IMPEDANCE

A tuned reflectometer system, developed at NBS, measures the magnitude of the reflection coefficient $|\Gamma|$ better than $\pm 0.001(1+3|\Gamma|)$, over the range from 0.001 to 1.0.

The accuracy of a reflection-coefficient measurement is limited to the dimensional tolerances achieved in fabricating the input waveguide section. In the NBS system, the internal dimensions of the WR-15 waveguide input section are uniform to ±15 millionths of an inch. This compares to commercial tolerances of 0.001 (1/1000) inch.

ANTENNA GAIN

On-axis antenna gain is measured



NBS Microcalorimeter was developed as a reference power standard at millimetre-wave frequencies. Accurate to ±0.3 percent, the calorimeter provides the basis for an absolute standard of power measurements in the 50- to 75-GHz range. With cover (left) in place, the device is submerged in a water bath maintained stable to within 25 microdegrees.

Automated Noise-Figure-Measurement System is a unique NBS facility developed to make NF measurements to an estimated accuracy of ±0.1 dB (2.3%). Waveguide switch, hot and cold source are combined in box (on table top). The unit, connected to device under test, employs temperature-controlled rotary-vane attenuator that alternates between minimum and maximum attenuation. Control system and minicomputer are contained in rack (right); teletypewriter provides commands for system control and printout of results.

Outdoor antenna extrapolation range employs two towers, movable on rails, that are precisely aligned. Separation distance between antennas is varied to obtain plot. Van in foreground houses receiver and data-gathering equipment (inset).

using two existing facilities, refitted for millimetre-wave frequencies. Two separate techniques permit results to be cross-checked and help resolve individual limitations, thus increasing the confidence and reliability of both measurement techniques.

One of the techniques, the outdoor extrapolation range, employs a standard and an unknown antenna located on two precisely aligned towers that move on rails. By varying the antenna separation distance, a plot can be derived of the received signal versus the separation distance. A computer then massages the data in various ways to consider all the known variables and their contributions. The essential feature of computer processing is to fit the measured data with a power series in powers of 1/distance which allows the far-field gain to be extrapolated to large distances.

The indoor range, a near-field scanning range, employs a probe that measures point by point the amplitude and phase of the antenna under test. The probe scans the near-field until a plane rectangular area has been scanned. Computer-processing of the data yields a 3-dimensional plot of the amplitude and phase of the antenna, thereby showing the pattern and side lobes.

These two measurement techniques agreed to approximately 0.12 dB in determining the on-axis gain for an arbitrary frequency using a reference antenna with an 18-in aperture. On-axis gain of the reference standard antenna is about 46.5 dB. Accuracies attained for these two measurement techniques

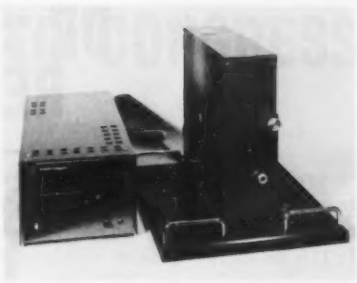
on the 18-in dish antenna are within ±3.5 and ±4.5 percent (0.15 to 0.19 dB) with the near-field technique being slightly more accurate.

NOISE

Two new WR-15 waveguide noise sources were developed by NBS for making noise-figure measurements to better than ±0.1 dB (2.3%) where circumstances permit this accuracy.

In the process of developing a facility for such measurements, a reference noise standard had to be developed. The standard is comprised of a lossy resistive element physically heated to a nominal 1000 °C and located in a platinum-rhodium-alloy waveguide. It has a calculable output accurate to about ±2.5 K. Comparable microwave units are accurate to about ±4.5 K. The NBS reference noise standard provides the basis for establishing an absolute standard of millimetre-wave noise measurements for the United States. To transfer the measurement base provided by the reference noise standard, a radiometer was developed based on switching-radiometer designs already employed at microwave freqencies. From these two, jointly used, a calibration service for WR-15 waveguide noise sources will be offered.

Some commercially available waveguide noise sources were found to be unstable in noise output and SWR. In fact, the magnitude of the SWR was so large as to negate other aspects of the program in achieving accurate noise-figure measurements. The two new NBS noise sources, one a 2-port device and the other a 1-port unit, yielded SWR's of nominally 1.08 and 1.05, respectively. Some commercially available neon waveguide noise sources at millimetre-wave frequencies have exhibited such unstable SWR's that a SWR measurement is impossible.



Modified rotary-vane attenuator offers electronic readout to 0.0005 degree.

NOISE FIGURE

Noise-figure measurements at millimetre-wave frequencies are not only a new NBS service, but noise-figure measurements in general are something NBS has always left to the commercial world. In microwave frequencies, noise-figure measurements more accurate than 0.5 to 1.0 dB are uncommon in spite of manufacturer's claims.

NBS developed a special facility with a goal of making noise-figure measurements to ±0.1 dB (2.3%). Resolution is of the order of 0.001 dB; precision is about 0.01 dB; accuracy has not been resolved at this time. Accuracy of a noise-figure measurement depends on the impedance match of both hot and cold noise sources to the device under test, to the gain stability of the device under test, etc. Thus, noise-figure measurement accuracy of the NBS system will not be positively established until some of the relationships are adequately understood. This will only come about through diverse experience gained by working with the system.

However, because the sensing element is a power meter, the measurement system yields average noise-figure rather than spot (single frequency) noise-figure measurements and can handle a wide variety of intermediate frequencies down to 10 MHz.

By using the radiometer as a comparator, the hot-source/switch combination head can be calibrated against the reference noise standard. This method permits the development of additional heads to extend the system into the microwave region.

For additional information about the NBS millimetre-wave calibration services, please contact F. X. Ries at (303) 499-1000, ext. 3561.

SOVIET *Continued*

could be distributed, and how they could be effective when they could not be enforced. They also found novel the idea that the user could have input into the actual development of a standard, as this seemed to pose a threat to objectivity.

Dr. Isayev concluded by noting that the U.S.S.R. is experimenting with methods of developing cost/effectiveness with regard to levels of accuracy, and that these methods would be demonstrated when the U.S. metrology team visits Russia in May.

The U.S. team will be headed by Dr. Ernest Ambler, Director of the Institute for Basic Standards, and will include the following Bureau staff members: Dr. Harold S. Boyne, Chief, Quantum Electronics Division; Dr. Karl G. Kessler, Chief, Optical Physics Division; Dr. James E. Leiss, Acting Director, Center for Radiation Research; Dr. John A. Molino, Sound Section; Dr. Walter L. Sadowski, Applied Mathematics Division; and Dr. Barry N. Taylor, Chief, Absolute Electrical Measurements Section.

The three industrial representatives on the team are Dr. Leonard S. Cutler, Director, Physical Research Laboratory, Hewlett-Packard Company; Robert E. Esch, Director of Engineering, Automation and Measurement Division, the Bendix Corporation; and Albert E. Johnson, Chief Engineer, Special Products, Moore Special Tool Company, Inc.

DE SIMONE RECEIVES CIVIL SERVICE LEAGUE AWARD

Dr. Daniel V. De Simone, who was Director of the U.S. Metric Study at the Bureau, was one of 10 top Federal career employees honored by the National Civil Service League at its 1972 Career Service Awards Banquet. For his leadership of the Bureau's 3-year U.S. Metric Study, Dr. De Simone received one of the two NCSL Career Service Awards for Special Achievement. On the basis of the Study, the Secretary of Commerce has recommended to the Congress that the United States convert to the metric system over a 10-year period. A metric conversion bill prepared by the Commerce Department has been submitted to Congress.

A Bureau staff member since 1964, Dr. De Simone is now assigned to the Executive Office of the President where he serves as an Assistant to the President's Science Advisor. He was made head of the U.S. Metric Study in September 1969, and under his creative direction the Congressionally authorized task was completed within the prescribed time and for less than half of the anticipated cost. He was responsible not only for conducting the Study, but for designing the strategy, selecting the issues, supervising the analysis, and personally writing the final summary document. That final report, *A Metric America: A Decision Whose Time Has Come*, is a model of clarity and balance. The object of wide-spread publicity, the report has received high praise from Government officials, the business community, scientists, and educators.

Both an engineer and a lawyer, Dr. De Simone came to the Commerce Department in 1962 from the Bell Telephone Laboratories where he was responsible for patent programs involving advanced electronics and communications technology. In 1963 he became Consultant to the Assistant Secretary of Commerce for Science and Technology and to the Office of Technical Services. He was named head of the Office of Invention and Innovation at NBS when it was established in 1964. In his present position as Assistant to the President's Science Advisor, Dr. De Simone is responsible for evaluating the entire range of Federal science and technology programs, particularly those that influence innovation in American industry.

Dr. De Simone received the Commerce Department's highest award, the Gold Medal for Distinguished Achievement in the Federal Service, for his authorship of *Technological Innovation: Its Environment and Management*. A gifted and prolific writer, he has authored or co-authored three other books and numerous articles and technical papers.

Active in both engineering and legal organizations, Dr. De Simone is a member of the bar of the U.S. Supreme Court and of the State of New York. He is also a member of the Institute of Electrical and Electronics Engineers, the American Bar Association, and the New York University Creative Science Program. For 8 years he has served as Executive Director of the National Inventors' Council. He has long been interested in United States cooperation with Latin America, and is an Advisor to the Organization of American States. At various times Dr. De Simone has been a consultant to Congressional committees and national commissions on technology, patents, technological innovation, and public policy.

METRIC AMERICA BILL SENT TO CONGRESS

Proposed legislation to help the United States switch over to use of the metric system of measurement from the common inch-quart-pound system within the next 10 years was sent to Congress on February 29 by Secretary of Commerce Peter G. Peterson. The legislation was introduced on March 6 by Congressman George P. Miller and 24 cosponsors as House Joint Resolution 1092, and on March 28 by Senator Norris Cotton as Senate Joint Resolution 219.

The legislation would create a National Metric Conversion Board to plan and coordinate a *voluntary* conversion process in which metric units like the metre, litre, and kilogram would become the most common units of measure in America as they are or soon will be in all other industrialized nations of the world. The Board, to be made up of 25 representatives of industry, trade associations, citizens groups, and government appointed by the President and the Congress, would assist industry and the public in adjusting to the use of metric measurement units.

The legislation is an outgrowth of recommendations by former Secretary of Commerce Maurice H. Stans, based on a 3-year study by NBS. The Report of the Metric Study, "A Metric America: A Decision Whose Time Has Come," was sent to Congress in July 1971.[2]

Secretary Peterson, in transmitting the proposed legislation to the Congress, underscored the need to act now:

"The time has come for a national decision to prepare to join the rest of the industrial world in adopting metric language and practices. America's position in the world market in coming decades could be impaired by adherence to our customary units of measurement. Further postponement of the program of coordinated metric conversion will only result in greater barriers to our international trade.

"Unless the United States makes the commitment to 'go metric' over this decade, international standards will not adequately reflect the needs and products of U.S. industry," Secretary Peterson added. "If American technology is to compete in the world market, standards used in the development of new U.S. products and technologies must be written into these international standards. This would ensure that other nations bear their fair share in the process of harmonizing world trade.

"I am recommending that the metric conversion program be extended over a decade and have the advantage of well-considered plans to ensure a minimum of difficulty and confusion. The job of planning this voluntary conversion would be placed in the hands of those most affected through representation on the National Metric Conversion Board.

"Although some sectors will find it advantageous to convert more quickly, others more slowly, a decade following agreement on the national voluntary plan should see the country through the awkward period of dual usage," Secretary Peterson said.

The United States is the last industrially developed nation which has not established a national policy committing itself and facilitating conversion to the metric system, although Congress in 1866 passed a law making it legal to use the metric system in commerce and trade. The 3-year study by the Bureau in cooperation with some 55 Government agencies, industry, and almost every sector of society, was completed in response to an Act of Congress. The report's recommendations were:

—That the United States change to the International Metric System deliberately and carefully;

—That this be done through a coordinated national program;

—That the Congress assign the responsibility for guiding the change, and anticipating the kinds of special problems described in the Report, to a central coordinating body responsive to all sectors of our society;

—That within this guiding framework, detailed plans and timetables be worked out by these sectors themselves;

—That early priority be given to educating every American schoolchild and the public at large to think in metric terms;

—That immediate steps be taken by the Congress to foster U.S. participation in international standards activities;

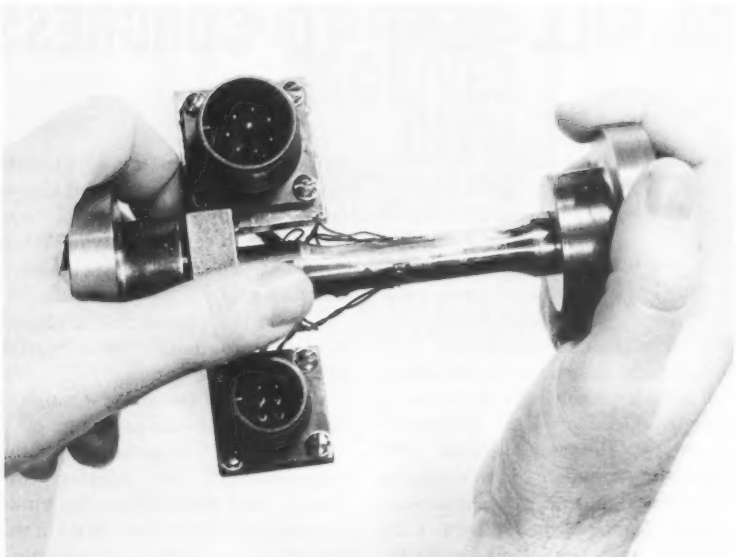
—That in order to encourage efficiency and minimize the overall costs to society, the general rule should be that any changeover costs shall "lie where they fall";

—That the Congress, after deciding on a plan for the Nation, establish a target date 10 years ahead, by which time the U.S. will have become predominantly, though not exclusively, metric; and

—That there be firm Government commitment to this goal.

[1]See A Metric America, NBS Tech. News Bull. Sept. 1971.

[2]Available from the Superintendent of Documents U.S. Government Printing Office, Washington, D.C. 20402, as NBS Spec. Pub. 345, 192 pages, $2.25. Use S.D. catalog No. C13.10:345.



Strain gages mounted axially at the smallest diameter of this steel test specimen are used to determine the indication error of fatigue testing machines. The output of the strain gages is first statically calibrated against known forces in a universal testing machine.

MEASURING DYNAMIC LOADS IN A FATIGUE MACHINE

INSTRUMENTED SPECIMEN SUPPLIES COMPARISON SIGNALS

Corrections that should be applied to readings of a fatigue testing machine have been found by a new test procedure. Donald C. Robinson, of the engineering mechanics laboratory, measured dynamic loads of a high-frequency electromagnetic fatigue testing machine and compared the loads indicated by the machine's dynamometer with those from test specimens with attached strain gages.[1] The resulting correction for excessive load errors makes possible more meaningful fatigue test results.

High-frequency fatigue testing machines are used for continuously applying sinusoidal forces to specimens to determine how long a material will last when subjected to fatigue in use. The specimens can be rods or strips of the material (usually cut down to a smaller dimension midway in their length), mechanical components such as bolts or fasteners, or structural members. The sinusoidal force applied to the specimen is indicated by a dynamometer that is built into the machine.

Small errors in the dynamometer indication are critical because they can cause a relatively large error in appraising the fatigue life of the specimen. Thus, application of slightly too small a force might result in early failures in service of a component thought to have a sufficiently long life, and *vice versa*. This effect was of interest to the U.S. Navy, sponsor of the background work for the present study, because of its concern with quality control for mechanical fasteners.

The NBS study made use of a high-speed fatigue testing machine, typical of those used for testing mechanical fasteners in industry. The machine is operated at the resonant frequency of the vibrating system by an electromagnetic driver that energizes a moving mass, to which the specimen and dynamometer are connected in series. The specimen is gripped by holders attached to the moving mass and to a second fixed mass.

INSTRUMENTED TEST SPECIMEN

The elastic devices used at the Institute for measuring the dynamic loads applied by the fatigue machine consisted of steel test bars, to each of which four strain gages were mounted axially at 90° intervals around its smallest diameter. The specimens used had been machined to diameters of 0.375, 0.500, and 0.750 inch to have specimen stiffnesses in the range of interest. The instrumented test bars were calibrated statically before use in a universal testing machine, the load indication of which was verified according to methods developed by the American Society for Testing and Materials.

When an instrumented test bar was installed in the fatigue machine, the outputs of the strain gages were compared with each other to discover if there was any bending due to eccentric loading. The mounting of the test fixture was adjusted until the differences among the strains indicated by any of the four gages were minimized.

Test loads indicated by the

machine's dynamometer were compared with those measured by the instrumented bars for several cyclic load ranges. The resolving power of the oscilloscope used to record the signals from these specimens was increased by use of a differential comparator amplifier. The ranges investigated ran from 150 to 4,500 lbf* for the 0.375-inch-diameter bar to 600 to 15,000 lbf for the 0.750-inch-diameter bar. Test frequencies ranged from 125 to 167 Hz for the smallest diameter bar and from 150 to 200 Hz for the largest diameter bar.

*Pounds force.

FINDINGS

The mean loads indicated by the instrumented bars were in each case less than those indicated by the machine's dynamometer. Load errors (the difference between mean load values indicated by the test bars and dynamometer) increased slightly with frequency and with the applied load; they were generally within 2 percent of the indicated load.

The load error was increased when an added component, a connector used for easier installation of fasteners in the fatigue machine, was inserted between the instrumented bar and the machine's dynamometer.

This investigation showed also that the load indication errors varied with the size, and therefore the stiffness, of the specimen. Since the stiffness of the specimen is known to influence the dynamic properties of the vibrating system, it is recommended that fatigue testing machines be calibrated with test bars representative in stiffness of the specimens to be tested.

[1] Robinson, D. C., Determination of Dynamic Loads in a High-Frequency Direct-Stress Fatigue Machine, Nat. Bur. Stand. (U.S.), Tech. Note 578 (June 1971), available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, as SD Catalog No. C13.46:578 at a cost of 95 cents.

TECHNOLOGY *Continued*

natural science or engineering context.

Perhaps all good science and technology academicians have now become convinced that civilian technology and the academic world are mismatched and that they should best go their own way. I hope not! The fact that the problems are not purely scientific and technological, but involve social and political factors, must be accepted as a given part of the challenge.

How can we proceed? I'd like to suggest some experimentation since we are entering a world in which the constraints are not well-defined and agreed-on methodologies are not yet available.

I mentioned the group in NBS that I'm involved with—the Institute for Applied Technology. Our redundant title indicates that we live in a real-world context. We are, or at least I am, very anxious to try to use our resources in a coupling mode to the university/industrial complex.

We have some significant resources. They include laboratory facilities, some capabilities in applied mathematics, and a number of system analysts. Perhaps most important we have a bunch of people who know what some of the nonsolutions are. To give examples:

1. In the building regulatory world, there are code officials at the local, county, and State levels, and we understand what they're about. We also know something about the building industry—its materials producers, its professional and technical committees, its multitude of trade and industry associations, and its concerns about rapid change.
2. In the fire area, we work with the firefighters union, the association of fire chiefs, the National Fire Protection Association, the insurance company laboratories, the independent test laboratories.

Our operations in these arenas are not always successful as measured by the sensitive Washington indicator of amount of Federal budget received. However, we are most anxious to engage the intellectual resources of the academic community in some real problems. We need to work closely together on problem definitions.

On the university side, there would have to be a willingness to experiment with a new type of involvement which does not conform to the DOD/NSF constraints. There would have to be a willingness to develop team capabilities which cross academic departmental lines. You might even have to learn to work jointly with members of the law and business schools while still maintaining a sound science/technology operation.

The rewards for being willing to experiment with this new type of interaction could well be great. First, there would be a satisfactory answer to those who seek to make their efforts relevant to some of society's most urgent problems. Second, the students and faculty involved will have the breadth of their interests broadened as they encounter problem areas in which their particular expertise can cast some light but clearly cannot develop a complete solution. Third, the university may indeed become a more effective community of scholars rather than a collection of discrete groups whose disciplinary concerns are separated.

Thus an interaction of the university with civilian-sector problems can strongly affect the university community as I am sure it will affect the civilian agencies of the Government.

It is my opinion that both will benefit in the process.

[1] Nelkin, D., The Politics of Housing Innovation: The Fate of the Civilian Industrial Technology Program, (Cornell University Press, 1971).

[2] Wright, J. R., Performance criteria in building, Scientific American **224**, No. 3, 16-25 (Mar. 1971).

CCST NEWS

The NBS Center for Computer Sciences and Technology, under P.L. 89–306, is the Federal Scientific and technical focal point for insuring that computer services meet the needs of the customer. Significant activities of the Center are reported in this column for the information of interested computer customers.

MINICOMPUTER SYMPOSIUM HELD AT NBS

On March 1, 1972, NBS hosted a symposium entitled "Minicomputers—Trends and Applications." The symposium was sponsored by the Eastern Area Committee and Washington, D.C., Chapter of the IEEE Computer Society, and was attended by an audience of some 650 people. Welcoming remarks were given by Dr. Ruth M. Davis, Director of the NBS Center for Computer Sciences and Technology, following an introduction to the symposium by James A. Cunningham of the National Weather Service, the conference chairman. Kenneth Olsen, President of the Digital Equipment Corp., provided the keynote address, "Minicomputers—A Challenge in the 70's." The symposium provided an opportunity for dialogue and audience participation in two panel discussions, one on buying a minicomputer without getting burned, and one on the use and abuse of minicomputers.

In her welcoming remarks, Dr. Davis presented statistics on the burgeoning numbers of minicomputers finding their way into the Federal inventory. She also identified eight major subindustries within the once-monolithic computer industry: manufacture of large mainframes, minicomputers, suppliers of peripherals, leasing organizations, software suppliers, computer services, facility management, and networking. In contrast to the relatively modest number of large mainframe manufacturers, there are currently more than 60 manufacturers of minicomputers, resulting in a keenly competitive situation. Dr. Davis also identified several subindustries that are prime fields for the application of minicomputers: automatic reading machines, computer research, process control, and automation. Dr. Davis concluded her remarks with the observation that the computer affords man the opportunity to exert a greater degree of control over his environment than ever before and noted that the rapidly proliferating minicomputer will play a very significant part in attaining such a goal.

Mr. Olsen, in his keynote address, discussed minicomputers in a philosophical key. He cited the difficulty of constructing an adequate definition of the term "minicomputer." This difficulty arises in no small measure from the rapid pace at which the minicomputer is evolving, with the capability of today's small machines equalling or exceeding that of the early large-scale machines. It is also possible to configure a system in which the minicomputer is only a small part of the total investment. Mr. Olsen noted that, as in the case of larger machines, minicomputer software costs can exceed the hardware costs by a substantial factor.

With a touch of whimsy, Mr. Olsen presented as the grandfather of the minicomputer the giant "Whirlwind" computer constructed at MIT in the early 1950's. It was not the size of this machine, with its thousands of vacuum tubes and towering equipment racks, to which Mr. Olsen was alluding, but rather the various features which it incorporated. Among these were the 16-bit word, parallel arithmetic, ferrite core memory, magnetic tape, oscilloscopic display, real-time clock, analog interface, and even an audio output device which could produce computer-generated tones. With regard to a suitable definition of the minicomputer, Mr. Olsen concluded that its key attributes could be identified as compactness and ease of use in the sense of being accessible to the user.

Mr. Olsen recollected that when the first PDP-1 was installed at the Lincoln Laboratories, it was made available to any and all users without charge. This was an innovation that was greeted with great enthusiasm at the time.

Computer people, according to Mr. Olsen, are prone to describe as "revolutionary" the major changes which have taken place in this fast-moving field. However, these "revolutions" actually proceeded very slowly at the time of their occurrence and were generally accompanied with much technical difficulty. Two major innovations were cited by Mr. Olsen as deserving of being considered revolutionary—magnetic cores and transistors, yet both of these were perfected only after years of painstaking research and experimentation. In his view, much of the best work at the present time is being done by users in specific application areas.

With regard to the possible impact of minicomputers on the market for larger machines, Mr. Olsen said that both classes of computers have sufficiently distinct roles to insure a continuing need for both. As an analogy, he contrasted the use of private automobiles with commercial airlines. The automobile is accessible, flexible, easy to use, and may be used at the owner's convenience; the airline is rigidly scheduled and must be highly disciplined, with the emphasis on maximum utilization of facilities.

Mr. Olsen concluded that the key attribute for success in the computer field is discipline, plus a large measure of patience.

The escalating cost of software was of key concern to all symposium participants. Evidence of light at the end of the tunnel was proclaimed by Dr. David Waks, Vice President of Applied Data Research, Inc., in a talk entitled "A Revolution in Minicomputer Software Preparation." Dr. Waks pointed out the desirability of compiling programs on a considerably larger system than the minicomputer system on which they are to run. With proper simulation tools and debugging aids, much of the program can be checked out on the larger system. While this approach offers great convenience, through the use of large-system facilities such as high-speed printers, card equipment, and displays, it generally suffers from the limitation of permitting only one user at a time to carry out debugging.

The typical program development cycle was described as consisting of program modification, language processing, and debugging; the goal of an automated programming system is to optimize this cycle of activities in order to expedite the development process. Illustrative of such a programming system is MIMIC, which runs on a PDP-10 computer and supports many of the common minicomputers. A set of desiderata for the ideal automated programming system was presented by Dr. Waks: It should use a machine-independent higher level language, appropriate application languages should be available with algorithms for a range of tasks, languages should be capable of being extended, the system should employ time-sharing rather than batch mode, debugging should be possible at the level of the source language, debugged programs should be compiled into efficient and compact programs for the target machine, the system should be economical, and there should be a means for the direct transfer of programs from the host machine to the target machine.

Machine organization was discussed in the talk, "New Dimensions in Minicomputer Architecture—What It Means to the User," presented by Dominik Archdale, Director of Marketing Operations for Interdata, Inc. He stated that new forms of logic and decreasing hardware costs are contributing to greatly increased flexibility in computer architecture. Special-purpose hardware, he said, can be provided for complex computations, execution of unique algorithms, and specialized tasks, such as the processing of telemetry data. Techniques for microprogramming are being implemented with a variety of new circuitry and offer the program designer the opportunity to create specialized sets of instructions. Mr. Archdale cautioned, however, that the effective use of this new flexibility requires a great deal of knowledge of both the hardware and the intended application; this requirement extends even beyond the knowledge presently required in the preparation of software.

Guidelines on the procurement of minicomputers were presented in a panel discussion, "How to Buy a Minicomputer and Not Get Burned," chaired by M. Pieter de Regt, of the Auerbach Corp. Martin Allen, of the Singer Co., dealt with the conversion of requirements into specifications and stressed the need to start with a careful examination of the task, rather than becoming preoccupied with hardware capabilities. The specification, he said, should be oriented toward the task rather than toward the hardware. In discussing system aspects, Frank Maczka, of Xerox Data Systems, cautioned against certain reoccurring planning deficiencies. He advised that special attention should be given to failure modes and recovery procedures; he also urged that systems be implemented in stages in order to minimize the risks and the check-out problems. In reviewing programming aspects, Philip Stein, of the NBS Office of Measurement Services, stressed the need for acquiring in-house expertise along with the installation of the minicomputer; otherwise subject area specialists will become engulfed in programming and diverted away from their specialties. Mr. Stein scored the difficulties of program preparation on the minicomputer with its limited storage and input/output facilities and noted that it is vastly better to use a cross-compiler on a larger machine.

Successful applications of minicomputers were discussed by several speakers. The high reliability attainable with these machines was described in a paper by Burt H. Liebowitz, of International Computing Co., and Richard S. Wolf, of American Totalisator Co. For applications in the field of business, the customer is increasingly turning to the computer supplier for a complete turnkey operation; this was the conclusion presented by Kenneth H. Kelly, of the Hewlett Packard Corp., and William F. von Meister, of Creative Associates, in describing an on-line data capture system developed for Western Union. Several examples were presented of minicomputers used in multiprocessor configurations for

real-time simulators, training aids, and process control by Paul L. Hazan of the Singer Co.

The second panel, "Minicomputers—Use and Abuse," was chaired by Murray Stein, of the International Computing Co. The importance of obtaining a fast program loading device was emphatically portrayed by Steven Silverman, of Computer Operations, Inc. Limiting factors in the application of minicomputers, according to James Orris, of Varian, have in the past been speed and cost; however, technology and production have now overcome these factors and the future limitations are projected to be software and interfacing. In drawing the discussion to a close, Dr. Herbert R. J. Grosch, Senior Research Fellow at the NBS Center for Computer Sciences and Technology, offered the suggestion that many of the bright, creative minds currently exploring computer time-sharing might find more immediately productive tasks by turning their energies to the harnessing of minicomputers for a spectrum of practical applications.

The symposium concluded with tours of NBS laboratories where minicomputers are incorporated in laboratory measurement systems.

The minicomputer symposium was regarded by its sponsors as an outstanding success, based upon the large attendance and the enthusiasm exhibited by the audience. Numerous members of CCST, in addition to Dr. Davis, participated as officials, speakers, and committee members. Staff members from laboratories throughout NBS, among the attendees, attested to the extensive interest in this timely subject.

NEW FIPS TASK GROUP ON OPTICAL CHARACTER RECOGNITION

The NBS Center for Computer Sciences and Technology recently formed Federal Information Processing Standards Task Group No. 11, Optical Character Recognition. The purpose of the Task Group is to determine the need for standards and guidelines in the subject area and, as deemed necessary, to develop detailed recommendations for proposed Federal Information Processing Standards and/or tutorial papers and guidelines for OCR users.

Under its assigned program the Task Group is to:

1. Survey the Federal community on the use or intended use of OCR with specific attention to character sets and codes and their relationship to ASCII Standards.

2. Review the proposed FIPS PUB on *Layout of Forms for OCR Input* to determine its adequacy and need as a Federal Standard or Guideline.

3. Identify and review industry proposed standards relating to OCR and recommend Federal Government positions on them as required.

4. Identify documents, or elements thereof, that should be proposed as Federal Standards.

5. Develop and propose any FIPS PUBS required.

6. Determine the need for and develop procedures to promote the writing and publication of tutorial papers and guidelines on OCR as advisory documents for users.

Participation in this task group is being solicited through the Interagency Committee on ADP. Anyone interested in contributing to these efforts should consult his agency's principal member of the Interagency Committee on ADP.

New Standard Helps Fight Mercury Pollution

A new Standard Reference Material, SRM 1630, Trace Mercury in Coal, has been issued to assist in the Nation's fight against mercury pollution. The standard is intended for use as a comparison material for determining the mercury content of unknown samples and for calibrating and evaluating measuring instruments.

Mercury present in coal is added to the air through combustion, and then washed by rain into soil and waterways. Abnormal amounts of mercury have been found in water, fish, and game birds in at least 33 of the 50 States.

It is known that mercury and mercury compounds, when accumulated in the human body above certain levels, can cause irreversible brain damage and death, and are equally toxic to most living creatures. Government, the scientific community, and industry have joined forces to track down the origins of excessive mercury levels in an effort to prevent the pollutant from contaminating water and food supplies. SRM 1630 represents one of several aspects of mercury pollution being attacked by the Bureau.

The new standard is a commercially available, low-bituminous coal ground to a particle size of 210 to 500 micrometres, and certified as having a mercury content of 0.13 parts per million (ppm) by weight. This provisional value is based upon neutron activation analysis. From a total of 500 packaged bottles, 30 were randomly selected for analysis. Duplicate determinations were made on 0.5-g portions of 25 of these bottles, and single determinations were made on the other five. It is expected that the final certified value will not vary by more than ±0.01 ppm from the provisionally certified value.

SRM 1630 may be purchased in 50-g units for $45 each from the Office of Standard Reference Materials, Room B314, Chemistry Building, National Bureau of Standards, Washington, D.C. 20234. Telephone: (301) 921-2045.

COMPUTER CHIEF WINS FEDERAL WOMAN'S AWARD

Dr. Ruth M. Davis, Director of the Bureau's Center for Computer Sciences and Technology, recently received the 1972 Federal Woman's Award for the outstanding contributions she has made throughout her Federal career. Six recipients are selected each year for the quality and efficiency of their Federal careers, their influence on major government programs, and their personal qualities of leadership, judgment, integrity, and dedication.

Dr. Davis, a mathematician and physicist, is one of the country's leaders in the field of computer technology. As Director of the Bureau's Computer Center, she has legislative responsibility to advise the Office of Management and Budget and the General Services Administration on ADP management and procurement policies. These duties extend to assisting other Federal agencies on specific automation problems.

Exhibiting superb technical competence and outstanding managerial ability, Dr. Davis has expanded her efforts beyond the improvement of the effective use of computers. She has attacked the larger problems of developing and maintaining a technological support system, insuring that computer services really meet customer needs, and protecting the citizen's right to privacy by limiting access to information stored in data banks. She has had notable success in resolving technological and policy obstacles that had hindered development of the full potential of the computer. Humanizing computer technology to reduce or eliminate undesirable impacts on the people it is intended to serve has also been one of her goals.

Dr. Davis' emphasis on performance measurement techniques rather than design standards, better software measurements, and increased use of teleprocessing is expected to result in savings of several hundred million dollars in the Federal sector alone. She is a leader in the application of automation technology to upgrade services for health care, environmental protection, education, law enforcement, transportation, housing, and other socially significant areas.

Dr. Davis began her Federal career in 1955 as a research mathematician in the Department of the Navy, and progressed through the Office of the Secretary of Defense where, as Staff Assistant for Intelligence and Reconnaissance, she became the first woman to hold a supergrade post in the Department of Defense. In 1967 she joined the National Institutes of Health's National Library of Medicine as Associate Director for Research and Development and Director of the Lister Hill National Center for Biomedical Communications. In these posts she combined the efforts of the Federal Government and the health care community to improve biomedical communications and to make computers more accessible to physicians in the delivery of health care services by applying computer networking and systems technology.

Educated at American University (B.S., mathematics) and the University of Maryland (M.A. and Ph. D., mathematics), Dr. Davis is a member of many professional societies. She has served as consultant to the Republic of China on the use of management information systems. A recipient of numerous awards and commendations, she is a Visiting Professor of Computer Sciences at the University of Pittsburgh. She has taught at the University of Maryland and lectures at several other universities.

NSRDS NEWS

The NSRDS was established to make critically evaluated data in the physical sciences available to science and technology on a national basis. The NSRDS is administered and coordinated by the NBS Office of Standard Reference Data.

FIRST ISSUE OF JOURNAL OF PHYSICAL AND CHEMICAL REFERENCE DATA PUBLISHED

The first issue of the new quarterly, *Journal of Physical and Chemical Reference Data*, has been published by the American Chemical Society and the American Institute of Physics for the National Bureau of Standards, U.S. Department of Commerce. The objectives, scope, and approach of the new journal were explained in an editorial by the Editor, David R. Lide, Jr., Chief, NBS Office of Standard Reference Data. The editorial is reprinted as follows:

> This is the first issue of a new journal which we hope will fill an important gap in the literature of the physical sciences. The subject matter of the journal is, in essence, the quantitative numerical data of physics and chemistry. The primary objective is to provide reliable reference values of such property data for the use of physicists, chemists, and those in other disciplines. In this sense, the *Journal of Physical and Chemical Reference Data* can be viewed as a means of evaluating, systematizing, and compacting one of the major components of the primary research literature—the quantitative property data which result from most experimental research efforts.
>
> The problems brought about by the scientific information explosion have been discussed so frequently and so eloquently by others that it is hardly necessary to repeat them here. The last two decades have seen the traditional mechanisms for scientific communication severely strained. Major changes in both the primary and secondary scientific literature are taking place, and we can expect these trends to accelerate. All discussions of this subject emphasize the need for more and better reviews and compilations, which bring together the research results reported in widely dispersed journals and distill the essential information into a manageable package.
>
> The rapid growth of the literature has accentuated another problem, that of assessing the quality of the published information. It is clearly not sufficient to retrieve every numerical value from the primary literature and make this mass of raw data available to a community of users, many of whom are unable to judge the reliability of the numbers without great expenditure of effort. The universal experience of data evaluators is that an uncomfortably large fraction of the published data in almost every field is less accurate than the claims of the original investigator. More than that, very few authors give sufficient information on the details of their experimental measurements to allow a meaningful assessment of accuracy by an independent party.
>
> The aim of this journal is to present, in a systematic manner, compilations of physical and chemical property data which have been critically evaluated by scientists who are knowledgeable in the pertinent field of research. The journal will not, however, be simply a collection of tables. The basic philosophy of the journal is that all compilations should be fully documented as to the source of the original measurements and the criteria used for selection and evaluation of the data. Thus many of the articles may take the form of critical reviews which discuss the sources of error in various experimental techniques and attempt to assess the over-all reliability of the data in a particular field. In addition to supplying data, we hope that such reviews will fulfill an educational function by pointing out both deficiencies in measurement practices and gaps in available information.
>
> The choice of a journal format for publishing reference data deserves further comment. The idea of a closed set of volumes such as the *International Critical Tables* has great attraction from the standpoint of user convenience, but the sheer volume of data makes such a publication infeasible today. The journal format offers an advantage in currency, since evaluation projects of long duration will be able to submit

small sections of their total task for publication as soon as they are completed. Furthermore, we hope that the educational functions previously referred to will be better served by a periodical of this type. Finally, the journal should provide a means of conducting a dialogue among users, evaluators, and generators of data. A *Comments* section is planned in which readers will have an opportunity to challenge or expand upon the conclusions of authors.

Another feature of the journal will be a section of *Data Compilation Abstracts*. These abstracts will cover compilations and reviews published elsewhere whose subject matter and approach are similar to that of the *Journal of Physical and Chemical Reference Data*. The abstracts will be indexed along with the articles which appear in the journal. In this way it is hoped that the journal will become an entry point to the rapidly growing world literature on evaluated property data.

Notwithstanding the advantages of a journal format, there is also a need for collected tables and monographs which give comprehensive coverage of the data in well-defined subject areas. We anticipate that *Supplements* to the *Journal of Physical and Chemical Reference Data* will be published at irregular intervals. These book-length publications will comprise either collections of material which have appeared previously in the journal or new material which is too lengthy for the journal format. The *Supplements* will be announced in the journal and included in the index.

One of the functions of the *Journal of Physical and Chemical Reference Data* is to provide an outlet for compilations and reviews produced by the National Standard Reference Data System. The NSRDS is a systematic national program on data evaluation, coordinated and partially supported by the National Bureau of Standards. In addition, contributions from sources outside this formal program will be encouraged. The participation of the American Institute of Physics and the American Chemical Society in sponsoring the journal is a recognition of the key role which individual scientists must play in this endeavor. We hope that the *Journal of Physical and Chemical Reference Data* will make its contribution to solving some of the complex problems of scientific communication.

FIRST ISSUE CONTENTS

Abstracts of the critical compilations included in the first issue are:

GASEOUS DIFFUSION COEFFICIENTS

T. R. Marrero and E. A. Mason

Diffusion coefficients of binary mixtures of dilute gases are comprehensively compiled, critically evaluated, and correlated by new semi-empirical expressions. There are 74 systems for which the data are sufficiently extensive, consistent, and accurate to allow diffusion coefficients to be recommended with confidence. Deviation plots are given for most of these systems. Almost every gaseous diffusion coefficient which was experimentally determined and reported prior to 1970 can be obtained from the annotated bibliography and table of gas pairs.

A detailed analysis of experimental methods is given, and intercomparison of their results helps establish reliability limits for the data, which depend strongly on temperature. Direct measurements are supplemented by calculations based on knowledge of intermolecular forces derived from independent sources—molecular beam scattering for high temperatures, and London dispersion constants for low temperatures. In addition, diffusion coefficients for several mixtures are obtained from experimental data on mixture viscosities and thermal diffusion factors. Combination of all these results gives diffusion coefficients over a very extensive temperature range, from very low temperatures to 10,000 K.

All data are corrected for composition dependence and for quantum effects. New semi-empirical equations are derived for making such corrections easily.

SELECTED VALUES OF CRITICAL SUPERSATURATION FOR NUCLEATION OF LIQUIDS FROM THE VAPOR

G. M. Pound

Selected values of critical supersaturations for homogeneous nucleation of droplets from the vapor and for heterogeneous nucleation of droplets on the natural stationary concentration of gaseous ions are tabulated and plotted. A rationale is given for selection of these data.

SELECTED VALUES OF EVAPORATION AND CONDENSATION COEFFICIENTS FOR SIMPLE SUBSTANCES

G. M. Pound

Tables of selected data on the coefficients of evaporation and condensation far from equilibrium for simple substances are presented, together with a rationale for the exclusion or choice of data and an estimate of the precision measure.

ATLAS OF THE OBSERVED ABSORPTION SPECTRUM OF CARBON MONOXIDE BETWEEN 1060 AND 1900

S. G. Tilford and J. D. Simmons

This atlas summarizes the results of a recent investigation of the carbon monoxide absorption spectrum between 1060 and 1900 Å. Twelve electronic transitions are observed in this region: four electric dipole

allowed electric transitions from the ground state X $^1\Sigma+$ to the A $^1\Pi$, B $^1\Sigma+$, C $^1\Sigma-$, and E $^1\Pi$ states, and eight forbidden transitions to the a' $^3\Sigma+$, e $^3\Sigma-$, a $^3\Pi$, D $^1\Delta$, d $^3\Delta i$, I $^1\Sigma-$, j $^3\Sigma+$, and c $^3\Pi$ states. The following items are presented in the atlas:

1. A photograph of the spectrum with band assignments;

2. a table of band head measurements and assignments arranged by wavelength;

3. a summary of the spectroscopic constants and potential curve for each electronic state;

4. a line list, arranged by wavelength, of the observed rotational lines of the allowed transitions.

TABLES OF MOLECULAR VIBRATIONAL FREQUENCIES

T. Shimanouchi

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Hamer, W. J., Thermodynamics of standard cells of the saturated cadmium sulfate type.

Khoury, F., and Barnes, J. D., The formation of curved polymer crystals: poly(4-methylpentene-1).

Sanchez, I. C., and DiMarzio, E. A., Dilute solution theory of polymer crystal growth: fractionation effects.

Sieck, L. W., and Ausloos, P., Photoionization of propylene, cyclopropane, and ethylene. The effect

of internal energy on the bimolecular reactions of $C_2H_6^+$ and $C_2H_6^+$.

Sparks, L. L., and Powell, R. L., Low temperature thermocouples: KP, "normal" silver, and copper versus Au-0.02 at% Fe and Au-0.07 at% Fe.

Verbeke, O. B., An improved state equation in the vicinity of the critical point.

Verges, J., Corliss, C. H., and Martin, W. C., Infrared spectra of cerium (Ce I and Ce II) between 0.8 and 2.4 μm.

J. Res. Nat. Bur. Stand. (U.S.), **75B** *(Math. Sci.),* Nos. 1&2 (Jan.-June 1972), SD Catalog No. C13.22/sec.B:76/1&2.

Dieter, U., Pseudo-random numbers: permutations of triplets.

Goldman, A. J., Minimax-based selection, adjustment and disaggregation for incompletely specified univariate distributions.

Horn, W. A., Three results for trees, using mathmetical induction.

Lechner, J., Efficient techniques for unbiasing a Bernoulli generator.

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Roth, C., Checks of the algebraic matrices for the configurations $(d+s)^n p$.

Tryon, P., Covariances of two sample rank sum statistics.

OTHER NBS PUBLICATIONS

Bechtoldt, C. J., An x-ray diffraction method for determining the amount of austenite in an austenite-ferrite mixture, Nat. Bur. Stand. (U.S.), Tech. Note 709, 15 pages (Feb. 1972) 30 cents, SD Catalog No. C13.46:709.

Bennett, L. H., Editor, Electronic density of states, Nat. Bur. Stand. (U.S.), Spec. Publ. 323, 834 pages (Dec. 1971) $7.75, SD Catalog No. C13.10:323.

Bloss, R. L., Orloski, M. J., Editors, Precision measurement and calibration—Mechanics, Nat. Bur. Stand. (U.S.), Spec. Publ. 300, Vol. 8, 590 pages (Jan. 1972) $6.25, SD Catalog No. C13.10:300/v.8.

Hamilton, W. F., Jespersen, J. L., Application of VLF theory to time dissemination, Nat. Bur. Stand. (U.S.), Tech. Note 610, 170 pages (Nov. 1971) $1.50, SD Catalog No. C13.46:610.

Hellwig, H., Barnes, J. A., Glaze, D. J., Kartaschoff, P., Frequency shifts due to Ramsey type interrogation in atomic beam tubes, Nat. Bur. Stand. (U.S.), Tech. Note 612, 25 pages (Feb. 1972) 35 cents, SD Catalog No. C13.46:612.

Mason, H. L., Peiser, H. S., Editors, Metrology and standardization in less-developed countries: The role of a national capability for industrializing economics, Nat. Bur. Stand. (U.S.), Spec. Publ. 359, 390 pages (Dec. 1971) $5, SD Catalog No. C13.10:359.

McNesby, J. R., Byerly, R., Jr., Measures for air quality, Annual Report FY 1971, Nat. Bur. Stand. (U.S.), Tech Note 711, 77 pages (Jan. 1972) 70 cents, SD Catalog No. C13.46:711.

Moore, C. E., Atomic energy levels—As derived from the analyses of optical spectra, Volume II, Nat. Stand. Ref. Data Ser., Nat. Bur. Stand. (U.S.), 35, Vol. II, 259 pages (Dec. 1971) $4.25, SD Catalog No. C13.48:35/v.II.

O'Connell, J. S., Electromagnetic multipole transitions in the recoupling picture, or electron scattering without curls, Nat. Bur. Stand. (U.S.), Tech. Note 713, 20 pages (Feb. 1972) 30 cents, SD Catalog No. C13.46:713.

Payne, J. E., Editor, Care of books, documents, prints and films, Consum. Inf. Ser. 5, 19 pages (Dec. 1971) 45 cents, Stock Number 0303-0941.

Peterson, C., Thomas, J. L., Cook, H., Editors, Aluminum wire tables, Nat. Bur. Stand. (U.S.), Handb. 109, 66 pages (Feb. 1972) 65 cents, SD Catalog No. C13.11:109.

Selby, M. C. Bolovac systems for measuring electrical quantities from 0.5 MHz through microwaves, Nat. Bur. Stand. (U.S.), Monogr. 123, 24 pages (Jan. 1972) 30 cents, SD Catalog No. C13.44:123.

Wegstein, J. H., Manual and computerized footprint identification, Nat. Bur. Stand. (U.S.), Tech. Note 712, 13 pages (Feb. 1972) 25 cents, SD Catalog No. C13.46:712.

White, H. S., Jr., Standards Coordinator, Guidelines for describing information interchange formats, Nat. Bur. Stand. (U.S.), Fed. Info. Process. Stand. Publ. (FIPS Pub) 20, 11 pages (1972) 25 cents, SD Catalog No. C13.52:20.

NBS OFFICE OF STANDARD REFERENCE DATA BIBLIOGRAPHY SERIES

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(COM-71-01103): Weekly List of Papers on Radiation Chemistry, Index and Cumulation Vol. IV, Nos. 1-26, January through June 1971, Radiation Chemistry Data Center, Radiation Laboratory, University of Notre Dame, August 1971, $6.

PUBLICATIONS IN OTHER JOURNALS

This column lists all outside publications by the NBS staff, as soon after issuance as practical. For completeness, earlier references not previously reported may be included from time to time.

Allan, D. W., Gray, J. E., Comments on the October 1970 Metrologia paper "The U.S. Naval Observatory clock time reference and the performance of a sample of atomic clocks," Metrologia **7**, No. 2, 79-82 (Apr. 1971).

Andrews, J. R., Horizontal time base sweep generator for a traveling wave oscilloscope, IEEE Trans. Nucl. Sci. **NS-18**, No. 5, 3-8 (Oct. 1971).

Argentar, H., Determination of the degree of polymerization of a polymeric amine from NMR data using a "least-squares" approach, J. Polymer Sci. **9**, Part B, 657-659 (1971).

Barnes, I. L., Sappenfield, K. M., Shields, W. R., The mass spectrometric analysis of subpicogram quantities of lead, (Proc. Int. Conf. Mass Spectroscopy, Kyoto, Japan, 1970), Chapter in Recent Developments in Mass Spectroscopy, K. Ogata and T. Hayakawa, Ed., pp. 682-687 (University of Tokyo Press, Tokyo, Japan, 1970).

Bates, R. G., Paabo, M., Measurement of pH, Handbook of Biochemistry, H. A. Sober, Ed., 2nd Edition, pp. J227-J233 (Chemical Rubber Company, Cleveland, Ohio, Jan. 1971).

Bederson, B., Kieffer, L. J., Total electron-atom collision cross sections at low energies—A critical review, Rev. Mod. Phys. **43**, No. 4, 601-641 (Oct. 1971).

Bennett, L. H., Carter, G. C., Enhanced lever rule for high-precision phase diagram determination, Met. Trans. **2**, 3079-3081 (Nov. 1971).

Berry, R. J., Riddle, J. L., Intercomparison of oxygen boiling point realizations in standards laboratories, Metrologia **7**, No. 2, 56-58 (1971).

Blandford, J. M., Bensing, P. L., Testing programs for the apparel industry. Evaluation of material and components—Parts I and II, Part I, 35 pages (2nd ed. May 15, 1971); Part II, 249 pages (May 15, 1971).

Block, S., The user's viewpoint on x-ray diffraction safety standards, Proc. Conf. Radiation Safety in X-ray Diffraction and Spectroscopy, University of Pennsylvania, Philadelphia, Pa., Jan. 6-7, 1970, pp. 211-221 (Sept. 1971).

Brady, G. W., Gravatt, C. C., Jr., Determination of the radial distribution function and the direct correlation function of spheres by x-ray small-angle scattering, J. Chem. Phys. **55**, No. 10, 5095-5101 (Nov. 15, 1971).

Brady, R. F., Jr., Enolization of hexodiulose acetals. Synthesis of derivatives of D-psicose by reduction of a hex-3-enulopyranose, Carbohydrate Res. **20**, 170-175 (Nov. 1971).

Brauer, G. M., A review of recent studies of *In Vitro* reactivity of surfaces of calcified tissues, (Proc. Int. Symp. Calcified Tissues, Dental and Surgical Materials and Tissue Material Interactions, University of Nijmegen, Nijmegen, The Netherlands, 1970), Dent. Tissues Mater. pp. 193-231 (1971).

Braun, W., Carlone, C., Carrington, T., Van Volkenburgh, G., Young, R. A., Collisional deactivation of H(2^2P) fluorescence, J. Chem. Phys. **53**, No. 11, 4244-4248 (Dec. 1, 1970).

Brown, W. E., Physicochemical aspects of decay and decalcification, (Proc. Int. Symp. Calcified Tissues, Dental and Surgical Materials and Tissue Material Interactions, University of Nijmegen, Nijmegen, The Netherlands, 1970), Dent. Tissues Mater. pp. 69-97 (1971).

Burdick, M. D., A test for the cleanability of surface finishes, Porcelain Enamel Inst. Bull. T-28, pp. 1-17 (1971).

Carter, G. C., Swartz, J. C., Nuclear magnetic resonance Knight shifts and quadrupole effects in transition metal diborides, J. Phys. Chem. Solids **32**, 2415-2421 (Jan. 1971).

Casella, R. C., The reversal symmetry and its breaking in physics, Phys. Teacher **8**, No. 3, 114-123 (Mar. 1970).

Cezairliyan, A., Recent developments in thermophysical properties research, Proc. Committee Thermophysical Properties, Washington, D.C, Dec. 1, 1971, HTD-3, 12-13 (American Society of Mechanical Engineers, New York, N.Y., 1971).

Cooper, M. J., Generalized scaling and the parametric equation of state in the critical region, Chapter in Critical Phenomena in Alloys, Magnets, and Superconductors, pp. 77-87 (McGraw-Hill Book Co., Inc., New York, N.Y., 1971).

Cooper, M. J., Various expansions in thermodynamic scaling, Phys. Rev. A **5**, No. 1, 318-320 (Jan. 1972).

Corliss, E. L. R., Estimate of the inherent channel capacity of the ear, J. Acoust. Soc. Am. **50**, No. 2, 671-677 (1971).

Coxon, B., Studies of ^{15}N-labeled amino sugars. The synthesis and mass spectrometry of derivatives of 6-amino-6-deoxy-D-glucose-6-^{15}N, Carbohydrate Res. **19**, 197-210 (1971).

Coxon, B., Johnson, L. F., The N.M.R. spectroscopy of derivatives of 6-amino-6-deoxy-D-glucose-6-^{15}N, ^{13}C Fourier-transform and internuclear, double- and triple-resonance studies, Carbohydrate Res. **20**, 105-122 (Nov. 1971).

Davis, J. E., The dry and wet bulb psychrometer, (Proc. ASHRAE Symp. Humidity Measurement, Columbus, Ohio, Feb. 5-8, 1968), Chapter in ASHRAE (Amer. Soc. Heat Refrig. Air-Cond. Eng.) Bull. Humidity Measurements, pp. 6-17 (May 1970).

Dean, J. A., Rains, T. C., Standard solutions for flame spectrometry, Chapter 13 in Flame Emission and Atomic Absorption Spectrometry II, 327-339 (Marcel Dekker, Inc., New York, N.Y., July 1971).

De Simone, D. V., Moving to metric makes dollars and sense, Harvard Bus. Rev., pp. 100-111 (Jan.-Feb. 1972).

Dibeler, V. H., Walker, J. A., McCulloh, K. E., Rosenstock, H. M., Effect of hot bands on the ionization threshold of some diatomic halogen molecules, Intern. J. Mass Spectrom. Ion Phys. **7**, 209-219 (1971).

DiMarzio, E. A., Rubin, R. J., Adsorption of a chain polymer between two plates, J. Chem. Phys. **55**, No. 9, 4318-4336 (Nov. 1, 1971).

Dise, J. R., Recent developments in cement testing, Proc. General Technical Committee, Portland Cement Association, San Francisco, Calif., Sept. 22, 1971, Mill Session Papers M-197, 34-42 (1971).

Distefano, G., Dibeler, V. H., Photoionization study of the dimethyl compounds of zinc, cadmium, and mercury, Intern. J. Mass Spectrom. Ion Phys. **4**, 59-68 (1970).

Durst, R. A., Ion-selective electrodes in science, medicine, and technology, Am. Sci. **59**, No. 3, 353-361 (May-June 1971).

Escalante, E., Kruger, J., Stress corrosion cracking of pure copper, J. Electrochem. Soc. 118, No. 7, 1062-1066 (July 1971).

Fatiadi, A. J., (p-Bromophenyl)osotriazoles from inositols, Carbohydrate Res. **20**, 179-184 (Nov. 1971).

Fraker, A. C., Ruff, A. W., Jr., Studies of oxide film formation on titanium alloys in saline water, Corrosion Sci. **11**, 763-765 (Dec. 1971).

Franklin, A. D., Theory of linear dielectrics, Proc. Conf. Electronic Phenomena in Ceramics, University of Florida, Gainesville, Fla., Nov. 10-14, 1969, Chapter 17 in pp. 451-489 (1971).

Flynn, T. M., Smith, C. N., Trends in cryogenic fluid production in the United States (Proc. Int. Institute of Refrigeration, Tokyo, Japan, 1970), Int. Inst. Refrig. Bull. Suppl. Commission I, pp. 241-247 (Annex 1970-2).

Goldstein, J. I., Yakowitz, H., Metallic inclusions and metal particles in the Apollo 12 lunar soil, Chapter in Proceedings 2nd Lunar Science Conference, Houston, Texas, Jan. 1971, 1, 177-191 (MIT Press, Cambridge, Mass., Mar. 1971).

Haar, L., Shenker, S. H., Equation of state for dense gases, J. Chem. Phys. **55**, No. 10, 4951-4958 (Nov. 15, 1971).

Hall, J. L., Barger, R. L., Bender, P. L., Boyne, H. S., Faller, J. E., Ward, J., Precision long path interferometry and the velocity of light, A. Smolinski, and S. Hahn, Ed. (Proc. URSI Conf. Laser Measurements, Warsaw, Poland, Sept. 24-26, 1968), Electron Technol. **2**, No. 2/3, 53-66 (Panstwowe Wydawnictwo Naukowe Polish Scientific Publ., Warsaw, Poland, 1969).

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